Course Outlines

1st Semester

DIGITAL TECHNOLOGY

Abstract
Fundamentals of digital technology: elementary building blocks, switching algebra, circuit analysis and synthesis, and design of finite automata.
Educational objective
You will:
- apply the fundamentals of digital technology;
- recognize and use the essential building blocks;
- analyze and develop digital circuits;
- systematically design finite automata;
- Gain experience in handling and assessing digital systems.
Content
- Basic concepts analog – digital
- Logical links
- Transistors in CMOS technology
- Switching algebra (Boolean algebra)
- Circuit analysis and synthesis
- Number systems and codes
- Combinatorial and sequential circuits
- Finite automata
- Memory and microprocessors
Script
Lecture slides, additional material, exercises with sample solutions.
https://iis-students.ee.ethz.ch/lectures/digital-circuits/

Literature
J. Reichardt, "Digital technology: an introduction with VHDL", 5th edition, De Gruyter Studium, 2021.

Requirements / Special
No special requirements required.

Competencies
Subject-specific skills
Concepts and theories checked
Processes and technologies checked
Method-specific competencies
Analytical skills checked
Problem solving checked

Social skills
Communication promoted
Cooperation and teamwork promoted

Personal skills
Creative thinking promoted
Critical thinking promoted

Assessment
Information on performance assessment (valid until the course unit is reread)

Performance assessment as a semester course
In the examination block for
Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Basic Examination Block A)

ECTS credits 4 CP

Test M. Luisier
Form Session Exam

Language of examination
German
Repetition
The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.

Examination mode
written 120 minutes

Additional information on the exam mode The exercises and intermediate tests are an important part of the course. The weekly exercise series as well as three intermediate tests are offered as learning elements: if you complete at least 75% of the weekly exercise series and submit it in time for correction and if you take part in two intermediate tests and submit your solution, the grade earned in the session exam will be increased by 0.25 grade points.
Aids in writing A maximum of 50 double-sided sheets (own summary, lecture slides, old exams...), no computer or communication system (mobile phone etc.), no book except the dictionary.
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

LINEAR ALGEBRA

Abstract
Contents: Systems of linear equations - Gauss's algorithm, matrices - LR decomposition, determinants, vector spaces, balancing calculus - QR decomposition, linear mappings, eigenvalue problem, normal forms - singular value decomposition; numerical aspects.
Educational objective
You can:
+ solve systems of linear equations using the Gauss algorithm;
+ apply the basic operations with vectors and matrices and interpret them geometrically;
+ calculate different matrix decompositions and apply them appropriately;
+ Calculate eigenvalues, eigenvectors and determinants of matrices;
+ Use properties of vector spaces and linear mappings;
+ formulate linear balancing problems and solve them with appropriate methods;
+ Understand and apply the singular value decomposition.
Content
+ Systems of Linear Equations, Matrices, Gauss Elimination, LU and QR Decompositions
+ Linear Spaces, Fundamental Theorem of Linear Algebra - Part I, Choice of Basis and Change of Base
+ Linear Maps and Mapping Matrix in Coordinate Transformations
+ Norm and Scalar Product in Linear Spaces, Gram-Schmidt Algorithm, Projectors
+ Linear Compensation Calculus
+ Determinants
+ Eigenvalues and Eigenvectors, Symmetric Matrices
+ Singular value decomposition and fundamental theorem of linear algebra, applications
Script Vasile Gradinaru, Linear Algebra, lecture notes at ETH Zurich (since 2014)
Literature Vasile Gradinaru, Linear Algebra, lecture notes at ETH K
. Nipp / D. Stoffer, Linear Algebra, vdf Hochschulverlag, 5th edition 2002
P. J. Olver and C. Shakiban "Applied Linear Algebra", 2nd ed. (2018)
Gilbert Strang "Introduction to Linear Algebra", 4th edition (2009)
Competencies
Subject-specific skills Concepts and theories checked
Processes and technologies checked
Method-specific competencies Analytical skills checked
Decision-making promoted
Problem solving checked
Social skills Communication promoted
Cooperation and teamwork promoted
Personal skills Creative thinking promoted
Critical thinking checked

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course

In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Basic Examination Block A)
Bachelor's Degree Programme Materials Science 2017; Issue 28.01.2020 (Examination block)
Bachelor's degree programme in Computational Sciences 2018; Issue 07.11.2024 (Basic Examination Block 1)
ECTS credits 5 CP
Test V. C. Gradinaru
Form Session Exam
Language of examination German
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode written 120 minutes
Additional information on the exam mode The exercises (including multiple choice) are an important part of the learning unit. The weekly exercise series are offered as learning elements as performance elements: In order to receive the bonus of 0.25 grade points for the exam, 75% of the tasks of 9 series must be meaningfully completed.
Aids in writing none
Digital Exam The exam takes place on equipment provided by ETH Zurich.
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

NETWORKS AND CIRCUITS I

Abstract
Fundamentals of electrical engineering: Stationary electric and magnetic fields, basic components of electrical circuits, DC networks, and electromagnetic induction.
Educational objective - They can trace current and voltage back to their physical origin.
- You can describe the properties of the basic components of electrical circuits with electric and magnetic fields.
- You will be able to mathematically describe, analyze and design circuit elements in their technical execution.
- You can calculate current and voltage distributions in DC networks.
- You can explain electromagnetic induction and transfer it to technical applications.
Content - Electrostatic Field
- Stationary Electric Flow Field
- Simple Electrical Networks- Power Line Mechanisms

- Stationary Magnetic Field
- Time-Varying Electromagnetic Field
Script Lecture slides, additional material, exercises with sample solutions on Moodle.
Literature Manfred Albach, Electrical Engineering
978-3-86894-398-6 (2020)
CompetenciesCompetencies
Subject-specific skills Concepts and theories checked
Processes and technologies checked
Method-specific competencies Analytical skills promoted
Media and digital technologies promoted
Problem solving promoted
Social skills Communication promoted
Cooperation and teamwork promoted
Personal skills Creative thinking promoted
Critical thinking promoted

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Basic Examination Block A)
ECTS credits 4 CP
Test C. Franck
Form Session Exam
Language of examination German
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.

Admission Requirements (Link)
Examination mode written 120 minutes
Additional information on the exam mode Independent preparation for the lecture and solving exercises and acquiring arithmetic routine is an important part of the course. For this purpose, learning elements are offered online, by working on which you can increase the grade obtained in the session exam by a maximum of 0.25 grade points (details will be announced at the beginning of the lecture). Only the points that were acquired through the course element in the immediately preceding autumn semester count. Crediting of older points is not possible.
Aids in writing Book Albach "Electrical Engineering", dictionaries, formula collection (max. 2 pages A4 = 1 sheet) - NO notes on exercises and old exams on the aids.
Digital Exam The exam takes place on equipment provided by ETH Zurich.
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

ENGINEERING MECHANICS

Abstract
Introduction to Technical Mechanics: Kinematics, Statics and Dynamics of Rigid Bodies and Systems.
Educational objective Through the basics of kinematics, statics and dynamics, students should gain a basic understanding of the subject matter with which simple problems of technical mechanics can be analyzed and solved. Based on this, advanced lectures can be attended that include mechanical knowledge as a prerequisite.
Content Basics: position and velocity of material points, rigid bodies, plane motion, kinematics of rigid bodies, force, moment, power.
Statics: Equivalence and reduction of force groups, center of forces and center of mass, equilibrium, principle of virtual performances, law of statics, bonds, analytical statics, friction.
Dynamics: acceleration, inertial forces, d'Alembert's principle, Newton's law of motion, momentum theorem, swirl theorem, swirl in plane motions.
Script yes
Literature M. B. Sayir, J. Dual, S. Kaufmann, E. Mazza: Engineering Mechanics 1, Fundamentals and Statics. Springer Vieweg, Wiesbaden, 2015.M
. B. Sayir, S. Kaufmann: Engineering Mechanics 3, Dynamics. Springer Vieweg, Wiesbaden, 2014.
CompetenciesCompetencies

Subject-specific skills	Concepts and theories	checked
Method-specific competencies	Analytical skills	checked
	Problem solving	checked
Social skills	Cooperation and teamwork	promoted
Personal skills	Customization and flexibility	promoted
	Creative thinking	promoted
	Critical thinking	promoted
	Integrity and Work Ethic	promoted
	Self-confidence and self-reflection	promoted
	Self-control and self-management	promoted

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Basic Examination Block A)
Bachelor's Degree Programme in Environmental Engineering 2022; Issue 07.11.2024 (Basic Examination Block A)
ECTS credits 4 CP
Test Fr. Tiso
Form Session Exam
Language of examination German

Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode written 120 minutes
Additional information on the exam mode During the semester, an intermediate examination is offered. Date, time, examination room as well as exact details of the examination mode and procedure will be communicated in the first weeks of the semester. Participation is voluntary. If the result of the intermediate examination is better than that of the session examination, this counts for 15% of the result of the session examination. If the result of the intermediate exam is worse, there is no negative effect on the score of the session exam. In addition, several small group projects are offered during the semester. Lego is used to assemble various systems and check their properties derived from the theory. By successfully completing all projects, a grade bonus of a maximum of 0.25 can be achieved, which is added to the grade calculated from the intermediate examination and session examination.

Only document-proof pens are allowed (no Tipp-Ex*, no pencil, no red or green pens). *Tipp-Ex may only be used for correcting multiple-choice answers on the corresponding answer sheet.
Aids in writing Summary (computer- or handwritten) on a maximum of 4 sheets of A4, which may be printed on both sides. Problems with solutions and old exams are not allowed. Own examples for illustration are permitted. The summary may be obtained from any source (e.g. the AMIV) as long as the above criteria are met. Neither calculators nor other electronic aids are permitted.
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

Analysis 1

Abstract Real and complex numbers, limits, sequences, series, power series, continuous mappings, differential and integral calculus of a variable, introduction to ordinary differential equations
Educational objective Introduction to the basics of analysis
Script Christian Blatter: Engineering Analysis (Chapters 1-4)
Literature Konrad Koenigsberger, Analysis I.Christian Blatter, Analysis I.
CompetenciesCompetencies
Subject-specific skills Concepts and theories checked
Processes and technologies checked
Method-specific competencies Analytical skills checked
Decision-making checked
Media and digital technologies promoted
Problem solving checked
Social skills Communication promoted
Cooperation and teamwork promoted
Personal skills Customization and flexibility promoted
Creative thinking promoted
Critical thinking checked
Integrity and Work Ethic promoted
Self-confidence and self-reflection promoted
Self-control and self-management promoted

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as an annual course with 401-0232-10L Analysis 2 (next semester)
For Regulations
(Examination Block) Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Basic Examination Block B)
Bachelor's Degree Programme in Computational Sciences 2018; Issue 07.11.2024 (Basic Examination Block 2)
ECTS credits 16 CP
Performance assessment as a semester course (other degree programmes)
ECTS credits 8 CP
Test F. Ziltener
Form Graded semester performance
Language of examination German
Repetition Repetition possible without retaking the course unit.
Admission Requirements This unit is usually tested together with Analysis 2 as a one-year course. In exceptional cases, a performance assessment of the semester course is possible after prior consultation with the lecturer.

Students in a degree programme where performance assessment is not required as a one-year course may register for the assessment as a one-year course, directly at the Examinations Office (registration is not possible via myStudies).
Additional information on the exam mode ATTENTION: The following information concerns the ANNUAL COURSE Analysis 1 and 2.
Learning elements are offered in the form of 2-weekly quizzes. In the following, for the sake of simplicity, "participant" means both "participant" and "participant". A participant of the course receives a grade bonus of 0.25 if he or she has answered all questions incorrectly in no more than 3 of the quizzes (on Analysis 1 and 2). Otherwise, he will not receive a grade bonus.
If a participant repeats the lecture and attends ONLY Analysis 2 this academic year, then he or she will receive a grade bonus of 0.25 if he or she has answered all questions incorrectly in no more than 2 of the Quizzes on Analysis 2. Otherwise, he will not receive a grade bonus.
Each quiz must be completed independently, without the help of others and without aids such as calculators or computers. (The computer may only be used to display the quiz on the Moodle page and to enter answers to the quiz questions.)
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

DIGITAL TECHNOLOGY INTERNSHIP

Abstract Basic terms analog - digital, number representation, combinatorial and sequential circuits, Boolean algebra, Karnaugh diagrams. Finite automata. Memory and computing modules in CMOS technology, programmable logic circuits.
Educational objective Deepening of the contents of the lecture and exercise, handling of design software Quartus II and oscilloscope
Content The contents of the practical course Digital Technology are intended to complement and further deepen the topics from the lecture and exercise of the same name. For this purpose, various circuits are graphically designed with the Quartus II design software for logical circuits and tested on an evaluation board. Among other things, a 7-segment display is controlled, an adder is set up and different types of latches and flip-flops are created. At the end of the internship, a small synthesizer is to be realized with which self-created melodies can be played. At the same time, the use of a modern oscilloscope is taught, which enables an analysis of the programmed circuits via its digital and analog inputs.
Script Manuscript of all attempts.
https://iis-students.ee.ethz.ch/lectures/digital-circuits/praktikum/
Requirements / Special No special requirements required
CompetenciesCompetencies
Subject-specific skills Concepts and theories checked
Processes and technologies checked
Method-specific competencies Analytical skills checked
Problem solving checked
Social skills Communication promoted
Cooperation and teamwork promoted
Personal skills Creative thinking checked
Critical thinking checked

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
ECTS credits 1 CP
Test M. Luisier, A. Emboras
Form Ungraded semester performance
Language of examination German
Repetition Repetition is only possible after re-registering for the learning unit.

PREPARATORY COURSE COMPUTER SCIENCE

Abstract The event offers an introduction to the basics of programming with C++. No programming experience is required.
Educational objective To build an understanding of basic concepts of imperative programming as well as for the systematic approach to programming problems. Students can read and write simple C++ programs.
Content This course introduces you to the basics of programming with C++. Programming means giving a computer a sequence of commands, the execution of which solves a specific problem.

The course is composed as follows:
- General introduction to computer science: development, goals, elementary concepts
- Interactive tutorial for self-study as an introduction to C++: variables, data types, branches and loops are covered - Introduction
to the systematic solution of programming problems by means of step-by-step refinement
- Two small programming projects: practical application of the basics learned
Script The learning material is available and usable entirely online; the programming projects are implemented in an online development environment.
CompetenciesCompetencies
Subject-specific skills Concepts and theories checked
Processes and technologies checked
Method-specific competencies Analytical skills checked
Media and digital technologies checked
Problem solving checked

2nd Semester

ANALYSIS 2

Abstract
Introduction to differential and integral calculus in several variables.
Educational objective - You can derive functions in multiple variables and apply the common derivation rules.
- You can integrate functions in multiple variables and apply common integration methods.
- You can apply the Gauss and Stokes theorems to vector fields in three-dimensional space.
Content - Differential calculus of several variables
- Integral calculus of several variables
- Maxima and minima
- Implicit functions
- Integration via submanifolds
- Theorems of Gauss and Stokes
Script F. Ziltener, Lecture notes for the lectures Analysis 1 and 2 for ITET and RW
Literature C. Blatter, Ingenieur Analysis 2, 2nd edition, Springer, 1996, ISBN: 978-3-540-60438-9
Requirements / Special CompetenciesCompetencies Analysis 1
Subject-specific skills Concepts and theories checked
Method-specific competencies Analytical skills checked
Problem solving checked
Social skills Communication checked
Cooperation and teamwork promoted

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as an annual course with 401-0231-10L Analysis 1
For Regulations
(Examination Block) Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Basic Examination Block B)
Bachelor's Degree Programme in Computational Sciences 2018; Issue 07.11.2024 (Basic Examination Block 2)
ECTS credits 16 CP
Test F. Ziltener
Form Session Exam
Language of examination German
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode written 240 minutes

Additional information on the exam mode Learning elements are offered in the form of 2-weekly quizzes. In the following, for the sake of simplicity, "participant" means both "participant" and "participant". A participant of the course receives a grade bonus of 0.25 if he or she has answered all questions incorrectly in no more than 3 of the quizzes (on Analysis 1 and 2). Otherwise, he will not receive a grade bonus.
If a participant repeats the lecture and attends ONLY Analysis 2 this academic year, then he or she will receive a grade bonus of 0.25 if he or she has answered all questions incorrectly in no more than 2 of the Quizzes on Analysis 2. Otherwise, he will not receive a grade bonus.
Each quiz must be completed independently, without the help of others and without aids such as calculators or computers. (The computer may only be used to display the quiz on the Moodle page and to enter answers to the quiz questions.)
Aids in writing 8 A4 pages of notes, self-written by hand on paper. (This corresponds to 4 A4 sheets written on both sides.) Other aids (e.g. books, formula collections and calculators) are not allowed.
Performance assessment as a semester course (other degree programmes)
ECTS credits 8 CP
Test F. Ziltener
Form Graded semester performance
Language of examination German
Repetition Repetition possible without retaking the course unit.
Admission Requirements This unit is usually tested together with Analysis 1 as a one-year course. In exceptional cases, a performance assessment of the semester course is possible after prior consultation with the lecturer.
Students in a degree programme where performance assessment is not required as a one-year course may register for the assessment as a one-year course, directly at the Examinations Office (registration is not possible via myStudies).
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

COMPUTER SCIENCE I

Abstract Introduction to programming with a focus on systematic and algorithmic problem solving. The programming language is C++.
Educational objective - You can create and structure simple programs using C++.
- You can explain and use fundamental control and data structures.
- You can describe the creation, translation, and execution of a program.
- You can solve problems with systematic and algorithmic thinking and map them meaningfully in a program.
Content - Fundamental data types, expressions and instructions
- Computer arithmetic, control instructions, functions, classes, references and pointers
- Characteristics and application of fundamental container types
- Structure and memory management of simple dynamic data types
- Motivation and illustration of the concepts by algorithms and applications
Script Lecture slides and additional material will be provided on the lecture website.
Literature - B. Stroustrup, Introduction to Programming with C++, 1st edition, Pearson Studies, 2010. ISBN: 978-3-86326-586-1
- S. Prata, C++ Primer Plus, 6th edition, Addison-Wesley, 2014. ISBN: 978-0-321-92842-9
CompetenciesCompetencies
Subject-specific skills Concepts and theories checked
Processes and technologies checked
Method-specific competencies Analytical skills checked
Media and digital technologies checked
Problem solving checked

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Basic Examination Block B)
ECTS credits 4 CP
Test M. Schwerhoff, R. Sasse
Form Session Exam
Language of examination German
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode written 120 minutes
Additional information on the exam mode By working on the weekly exercise series, a bonus of a maximum of 0.25 grade points can be earned, which is taken to the exam. The bonus is proportional to the number of points achieved in specially marked bonus tasks, with full points corresponding to a bonus of 0.25. Admission to specially marked bonus tasks may depend on the successful completion of other practice tasks. The achieved grade bonus expires as soon as the lecture is reread.

Aids in writing You may take a maximum of 4 A4 sheets with you to the exam. There are no content and formal requirements (text, images, single/double-sided, margins, font size, etc.). Electronic devices or digital documents are not permitted.

You may take up to 4 A4 sheets into the exam. There are no constraints regarding content and layout (text, images, single/double page, margins, font size, etc.). Electronic devices and digital documents are not allowed.
Digital Exam The exam takes place on equipment provided by ETH Zurich.
Remote Testing It is not possible to take it as a remote examination.
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

MATHEMATICAL METHODS

Abstract Basics of complex analysis in theory and application and introduction to integral transformations with treatment of some applications.

Educational objective - You can use the basic tools of complex analysis.
- You can apply differential and integral calculus to complex-valued functions.
- You can develop functions in Taylor, Laurent & Fourier series.
- You can analyze periodic functions using the Fourier transform.
- You can solve initial value problems using the Laplace transform.

Content - Complex Numbers and Functions, Complex Derivatives and the Cauchy Riemann Equations
- Complex Integration
- Residual Theorem and Applications
- Taylor and Laurent Series
- Fourier Series and Fourier Transformations
- Laplace Transformations

Script M. Akveld, A. Iozzi & P. Jossen, Mathematical Methods, 2025 (available on Moodle)

Literature - J. Brown, R. Churchill, Complex Analysis and Applications, 9th edition, McGraw-Hill Education, 2013. ISBN: 978-0073383170.

- T. Needham, Visual Complex Analysis, 25th Anniversary Edition, Oxford University Press, 2023. ISBN: 978-0191964947.

- E. Kreyszig, Advanced Engineering Mathematics, 10th edition, John Wiley & Sons Inc., 2011. ISBN: 978-0470458365.

- P., An Introduction to Laplace Transforms and Fourier Series, 2nd edition, Springer, 2014, ISBN: 978-1-4471-6395-4.

Requirements / Special CompetenciesCompetencies Analysis 1, Analysis 2 (accompanying)

Subject-specific skills Concepts and theories checked
Processes and technologies checked
Method-specific competencies Analytical skills checked
Problem solving promoted
Personal skills Creative thinking checked
Critical thinking checked

Assessment

Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Basic Examination Block B)
Bachelor's Degree Programme in Computational Sciences 2018; Issue 07.11.2024 (Basic Examination Block 2)

ECTS credits 4 CP

Test M. Akveld, C. Urech
Form Session Exam
Language of examination German
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode written 120 minutes
Additional information on the exam mode A weekly online QUIZ is converted into a grade bonus from 0 to 0.25 and then added unrounded to the unrounded grade from the session exam.
Aids in writing 4 A4 pages (= 2 sheets) of self-written notes. No calculator, no books.
Digital Exam The exam takes place on your own device. Installation of SEB required.
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

NETWORKS AND CIRCUITS II

Abstract Complex AC calculation, methods and sets of network calculation; networks with non-sinusoidal periodic excitation, switching operations, Fourier and Laplace transforms; transfer function, two-gates; basic amplifier circuits, push-pull and differential amplifiers; Operational amplifiers, operational amplifier basic circuits and applications.
Educational objective be able to apply methods of complex alternating current calculation and network calculation; Understand and calculate transition and transmission behavior of electrical networks in the time and frequency domain, understand, dimension and calculate basic circuits with operational amplifiers.
Content Complex alternating current calculation, methods and sets of network calculation, mesh current method, account potential method; networks with non-sinusoidal periodic excitation, Fourier decomposition, time and frequency domain; Switching Processes in Electrical Networks, Transition Behavior, Fourier Transform, Laplace Transform; transmission function of networks, two-gates; basic amplifier circuits, push-pull amplifiers and differential amplifiers; Operational amplifiers, basic operational amplifier circuits; Circuits with op-amps.
Script Lecture notes are available in Moodle. In addition, the literature cited describes the lecture content for the most part.
Literature Electrical engineering; Manfred Albach; 2nd edition; 688 pages; Pearson Studies 2020; ISBN: 9783868943986

Fundamentals of Electrical Engineering – Networks; 2nd edition; 384 pages; Schmidt / Schaller / Martius; Pearson Studies 2014; ISBN: 978-3-8689-4239-2

Microelectronic Circuits; 7th edition; 1472 pages; Sedra / Smith; Oxford University Press 2015; ISBN: 9780199339143

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Basic Examination Block B)
ECTS credits 8 CP
Test J. Biela
Form Session Exam
Language of examination German
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode 150 minutes in writing
Additional information on the exam mode The exercises are an important part of the course. The weekly exercise series are offered as learning elements: If you complete the exercises in Moodle on time and score enough points, the grade earned in the session exam will be increased by up to 0.25 grade points.

Aids in writing Lecture books/slides/scripts (GdE Albach/Schaller, Microelectr.Circuits) without notes on exercises/old exams, calculators without interface/memory, summary (will be distributed to exams), dictionaries.
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

PHYSICS I

Abstract Physics I is an introduction to continuum mechanics, wave phenomena, and fundamental aspects of thermodynamics.
Educational objective At the end of this course, students should be able to create and apply simple models of dynamics in deformable materials. In addition, they should be familiar with state variables in equilibrium systems under given realistic boundary conditions and be able to relate them to each other.
Content The lecture has the following topics:

Waves
- One-dimensional wave equation
- Planar waves, Spherical waves
- Elastic waves, Speed
of sound - Standing waves, Resonance
- Wave propagation: interference and diffraction
- Doppler effect

Thermodynamics
- Kinetic gas theory, perfect gases
- Conservation of energy, first law
- Second Law, Thermal Cycle Processes
- Entropy, Thermodynamic and Statistical Interpretation- Thermal
Radiation and Heat Transfer
Script The script will be posted on Moodle.
Literature P.A. Tipler and G. Mosca, "Physics: for Scientists and Engineers" (6th edition) chapters 14-20.
Requirements / Special Engineering Mechanics, Analysis

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Basic Examination Block B)
ECTS credits 4 CP
Test A. Imamoglu
Form Session Exam
Language of examination German
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode written 120 minutes
Aids in writing Calculators without communication (see D-ITET Calculator Guidelines for Examinations).
Translation dictionary.

If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

NETWORKS AND CIRCUITS INTERNSHIP

Abstract Experimental deepening of the knowledge imparted in the courses Networks and Circuits I and II using the example of inductive energy transmission systems (parameters of equivalent circuits, transmission characteristics, resonance compensation, high-voltage generation) and photovoltaics (characteristics of a solar module, power adjustment with DC-DC converters, electromech. energy conversion).
Educational objective In a modern laboratory environment, various core topics of the lectures and exercises on networks and circuits I and II are to be made practically tangible and consolidated. The illustrative experiments from the fields of inductive energy transmission and photovoltaics also allow students to learn a methodical experimental approach, how to use modern measuring devices and clear documentation of the results.
Content The practical course Networks and Circuits deals with core topics of the lectures and exercises on Networks and Circuits I and II. Lecture contents are presented in a vivid, practical way and shown in the context of selected industrial applications:

Inductive Energy Transfer (topics: parameters of equivalent circuits, transmission characteristics, resonance compensation, high-voltage generation).

Photovoltaics (topics: characteristic curve and performance characteristics of a solar module, power adaptation with power electronic converters, electromechanical energy conversion).

After the metrological and experimental examination of components and subsystems, the overall function is always treated and analysed in order to promote the ability to abstract and to address synthesis in addition to analysis. Other important goals are to get to know modern measuring instruments and their operation as well as to convey the importance of methodical planning and implementation of experimental investigations and clear conclusive documentation.
Script Experimental instructions
Literature Lecture Notes Networks and Circuits I and II

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
ECTS credits 1 CP
Test J. Biela
Form Ungraded semester performance
Language of examination German
Repetition Repetition is only possible after re-registering for the learning unit.
Additional information on the exam mode You can deregister from the internship until the end of the 4th week of the semester. After that, a non-appearance/participation in the internship will lead to discontinuation.

3rd Semester
ANALYSIS 3

Abstract In this lecture we treat problems in applied analysis. The focus lies on the solution of quasilinear first order PDEs with the method of characteristics, and on the study of three fundamental types of partial differential equations of second order: the Laplace equation, the heat equation, and the wave equation.
Educational objective The aim of this class is to provide students with a general overview of first and second order PDEs, and teach them how to solve some of these equations using characteristics and/or separation of variables.
Content 1.) General introduction to PDEs and their classification (linear, quasilinear, semilinear, nonlinear / elliptic, parabolic, hyperbolic)

2.) Quasilinear first order PDEs
- Solution with the method of characteristics
- Conservation laws

3.) Hyperbolic PDEs
- wave equation
- d'Alembert formula in (1+1)-dimensions
- method of separation of variables

4.) Parabolic PDEs
- heat equation
- maximum principle
- method of separation of variables

5.) Elliptic PDEs
- Laplace equation
- maximum principle
- method of separation of variables
- variational method

Literature Y. Pinchover, J. Rubinstein, "An Introduction to Partial Differential Equations", Cambridge University Press (May 12, 2005)
Requirements / Special Prerequisites: Analysis I and II, Fourier series (Complex Analysis)
CompetenciesCompetencies
Subject-specific skills Concepts and theories checked
Processes and technologies checked
Method-specific competencies Analytical skills checked
Decision-making checked
Media and digital technologies promoted
Problem solving checked
Social skills Communication promoted
Cooperation and teamwork promoted

Personal skills	Creative thinking	promoted
	Critical thinking	checked
	Integrity and Work Ethic	promoted
	Self-confidence and self-reflection	promoted
	Self-control and self-management	promoted

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Examination block 1)
Bachelor's degree programme in Computational Sciences 2018; Issue 07.11.2024 (Examination block G1)
ECTS credits 4 CP
Test F. Ziltener
Form Session Exam
Language of examination German
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode written 180 minutes
Aids in writing Subject-neutral dictionary

Two A4 sheets = four A4 pages Notes written by hand on paper
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

PHYSICS II

Abstract The goal of the Physics II class is an introduction to quantum mechanics

Learning objective To work effectively in many areas of modern engineering, such as renewable energy and nanotechnology, students must possess a basic understanding of quantum mechanics. The aim of this course is to provide this knowledge while making connections to applications of relevancy to engineers. After completing this course, students will understand the basic postulates of quantum mechanics and be able to apply mathematical methods for solving various problems including atoms, molecules, and solids. Additional examples from engineering disciplines will also be integrated.

Content Content:
- Wave mechanics: the old quantum theory
- Postulates and formalism of Quantum Mechanics
- First application: the quantum well and the harmonic Oscillator
- QM in three dimension: the Hydrogen atom
- Identical particles: Pauli's principle
- Crystalline Systems and band structures
- Quantum statistics
- Approximation Methods
- Applications in Engineering
- Entanglement and superposition

Lecture notes Lecture notes (hand-written) will be distributed via the Moodle interface

Literature David J. Griffiths, "Introduction to quantum mechanics" Second edition, Cambridge University Press.

Link

Prerequisites / Notice Prerequisites: Physics I.

CompetenciesCompetencies

Subject-specific Competencies	Concepts and Theories	assessed
Method-specific Competencies	Analytical Competencies	assessed
Problem-solving	assessed	
Personal Competencies	Creative Thinking	assessed
Critical Thinking	assessed	

Performance assessment

Performance assessment information (valid until the course unit is held again)

Performance assessment as a semester course

In examination block for Bachelor's Degree Programme in Electrical Engineering and Information Technology 2017; Version 07.11.2024 (Examination Block 1)

ECTS credits 8 credits

Examiners G. Scalari

Type session examination

Language of examination English

Repetition The performance assessment is offered every session. Repetition possible without re-enrolling for the course unit.

Mode of examination written 180 minutes
Written aids A formula sheet (provided before in the moodle interface and along with the text of the exam); a simple (non-programmable) pocket calculator.
Distance examination It is not possible to take a distance examination.
If the course unit is part of an examination block, the credits are allocated for the successful completion of the whole block.
This information can be updated until the beginning of the semester; information on the examination timetable is binding.

SIGNAL AND SYSTEMS THEORY I

Abstract Signal theory and systems theory (continuous and discrete time): signal analysis in the time and frequency domain, signal spaces, Hilbert spaces, generalized functions, linear time-invariant systems, sampling theorems, discrete-time signals and systems, digital filter structures, discrete Fourier transform (DFT), finite-dimensional signals and systems, fast Fourier transform (FFT).
Educational objective Introduction to Mathematical Signal Theory and Systems Theory.
Content Signal theory and systems theory (continuous and discrete time): signal analysis in the time and frequency domain, signal spaces, Hilbert spaces, generalized functions, linear time-invariant systems, sampling theorems, discrete-time signals and systems, digital filter structures, discrete Fourier transform (DFT), finite-dimensional signals and systems, fast Fourier transform (FFT).
Script Lecture notes, exercise notes with solutions.

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Exam Block 1)
ECTS credits 4 CP
Test H. Bölcskei
Form Session Exam
Language of examination German
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode written 180 minutes
Aids in writing As an aid during the exam, the collection of
formulas that you will receive from us at the beginning of the exam is permitted. The use of computers/smartphones/tablets of any kind or written documents is not permitted.
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

COMPUTER SCIENCE II

Abstract The course covers the fundamentals of designing and analyzing algorithms and data structures, including graph theory and problems. It provides an introduction to generic and parallel programming.
Educational objective Understanding of the design, analysis and implementation of fundamental algorithms and data structures. Overview of the concepts of generic and parallel programming. Experience in the practical implementation of all this in C++.
Content * Asymptotic runtime (algorithmic complexity)
* Fundamental algorithmic problems, e.g. searching, sorting, shortest paths, spanning trees
* Classical data structures, e.g. search trees, balanced trees, heaps, hash tables
* Graph theory and problems
* Problem-solving strategies as design patterns for algorithms, e.g. induction, divide-and-conquer, backtracking, dynamic programming
* Generic programming: C++ templates, higher-order functions, lambdas, closures
* Parallel programming: (In)independence of calculations, parallelism and concurrency, shared memory, race situations, mutual exclusion, communication and synchronization

In the practice mode, the understanding is deepened through theoretical and/or programming tasks (C++, Code Expert).
Script All material (slides, lecture recordings, examples, exercises, etc.) will be published on the course website or on Code Expert.
Literature * T. Ottmann, P. Widmayer: Algorithms and Data Structures, Spektrum-Verlag, 5th edition, Heidelberg, Berlin, Oxford, 2011
* T. H. Cormen, C. E. Leiserson, R. Rivest, C. Stein: Algorithms - An Introduction, Oldenbourg, 2010
* B. Stroustrup, The C++ Programming Language, 4th Edition, Addison-Wesley, 2013.
* B. Stroustrup, A Tour of C++, 3rd Edition, Addison-Wesley, 2022
Requirements / Special Prerequisites: Computer Science I
CompetenciesCompetencies
Subject-specific skills Concepts and theories checked
Processes and technologies checked
Method-specific competencies Analytical skills checked
Decision-making promoted
Media and digital technologies checked
Problem solving checked
Social skills Communication promoted
Cooperation and teamwork promoted
Personal skills Creative thinking promoted
Critical thinking promoted

Assessment
Information on performance assessment (valid until the course unit is reread)

Performance assessment as a semester course
In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Exam Block 1)
ECTS credits 4 CP
Test F. Friedrich Wicker, R. Sasse
Form Session Exam
Language of examination German
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode written 120 minutes
Additional information on the exam mode By working on the weekly exercise series, a bonus of a maximum of 0.25 grade points can be earned, which is taken to the exam. The bonus is proportional to the number of points achieved by specially marked bonus tasks, with full points corresponding to a bonus of 0.25. Admission to specially marked bonus tasks may depend on the successful completion of other practice tasks. The achieved grade bonus expires as soon as the lecture is reread.
The exam is expected to be conducted on the computer.
Aids in writing You may take a maximum of 4 A4 sheets with you to the exam. There are no content and formal requirements (text, images, single/double-sided, margins, font size, etc.). Electronic devices or digital documents are not permitted.

You may take up to 4 A4 sheets into the exam. There are no constraints regarding content and layout (text, images, single/double page, margins, font size, etc.). Electronic devices and digital documents are not allowed.
Digital Exam The exam takes place on equipment provided by ETH Zurich.
Remote Testing It is not possible to take it as a remote examination.
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

SEMICONDUCTOR CIRCUIT TECHNOLOGY

Abstract Introductory lecture in semiconductor circuit technology. The transistor as an active component. Analysis and design of transistor-based electronic circuits such as amplifiers and filters; Operational amplifiers and circuits based on them.
Educational objective Modern transistor-based electronic circuits have changed our lives and have played a key role in our economy for half a century. The main goal of this lecture is to introduce students to the concept of the active component. This includes op-amps and their application for amplifier circuits, signal conditioning, switching functions and filters. In addition to dealing with typical electronic circuits found in common applications including group work and practical courses, students can deepen their knowledge of linear circuits based on non-linear components. Non-idealities of electronic circuits and design concepts (as the opposite of analysis) are also discussed. The course is a prerequisite for topics such as analog integrated circuits, RF circuits for wireless communication, A/D and D/A converters and optoelectronics, which are offered in higher semesters.
Content Recapitulation of the transistor as a component (bipolar and MOSFET), large and small signal behavior, operating point and operating point setting. Single transistor amplifier, easy feedback to operating point adjustment. Frequency response of simple amplifiers. Bandwidth Expansion Methods. Differential Amplifiers, Operational Amplifiers, Variable Bandwidth Amplifiers. Instrumentation amplifiers: Common mode rejection, noise, interference signals, chopper technology. Transimpedance amplifier. Active filters: simple active filters, filters with bisquare levels. Higher-order filters, realization with bisquare steps and with conductor structure. Switched-cap filters.
Literature Göbel, H.: Introduction to Semiconductor Circuit Technology. Springer-Verlag Berlin Heidelberg, 6th edition, 2019.Pederson

, D.O. and Mayaram, K.: Analog Integrated Circuits for Communication. Springer US, 2nd edition, 2008.Sansen

, W.M.C.: Analog Design Essentials. Springer US, 1st edition, 2006.Su

, K.L.: Analog Filters. Springer US, 2nd edition, 2002.

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Exam Block 2)
ECTS credits 4 CP
Test H. Wang
Form Session Exam
Language of examination English
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.

Examination mode written 120 minutes
Additional information on the exam mode The exercises are an important part of the course. The weekly exercises are offered as a "continuous performance assessment": if you complete 10 exercises and hand them in time for review, the grade earned in the session exam will be increased by 0.25 grade points.

In addition, there will be two short in-class mid-term exams (quizzes), that each count as a bonus of 5% towards the final grade (10% total).
Aids in writing 5 A4 sheets double-sided (= 10 pages) of notes written by hand or machine.
Pocket calculator not capable of communication!
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

DISCRETE MATHEMATICS

Abstract Introduction to Discrete Mathematics Fundamentals: Set Theory, Combinatorics, Graph Theory, and Algebra. The basics are illustrated with applications from information technology.
Educational objective - You can use set theory and its axioms as the basis of mathematics.
- You can apply the elementary counting forms and principles from combinatorics to counting problems.
- You can explain the basic types of graphs and their properties.
- You can determine the solution of classical graph problems (e.g. flows in networks).
- You can use elementary number theory for applications of information theory.
- You can describe the basic algebraic structures and use them for error correction procedures.
Content The course covers the following areas of discrete mathematics:
- Set theory
- Combinatorics: elementary forms of counting, counting principles, and special counting problems
- Graph theory: properties, types (networks, trees, ...), coloring, flows & sections, and matchings
- Algebra: elementary number theory (divisible, congruence, ...), introduction to cryptography, groups, fields, and rings.
Script Lecture notes will be provided via Moodle.
Literature C. Boschini, A. Hansen, S. Wolf, Discrete Mathematics, vdf Hochschulverlag, 1st edition, 2022 (ISBN: 978-3-7281-4110-1).
CompetenciesCompetencies
Subject-specific skills Concepts and theories checked
Processes and technologies checked
Method-specific competencies Analytical skills checked
Problem solving checked
Social skills Communication promoted
Cooperation and teamwork promoted
Personal skills Creative thinking promoted
Critical thinking promoted

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Exam Block 2)
ECTS credits 4 CP
Test U. Koch
Form Session Exam
Language of examination German
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode written 120 minutes

Additional information on the exam mode Quizzes are published during the semester as learning elements, the successful solution of which can improve the final grade by up to 0.25 points.
Aids in writing None
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

SEMICONDUCTOR CIRCUIT TECHNOLOGY INTERNSHIP

Abstract Practical course with basic experimental circuits based on transistors and op-amps.
Educational objective Modern transistor-based electronic circuits have changed our lives and have played a key role in our economy for half a century. The main goal of this lecture is to introduce students to the concept of the active component. This includes op-amps and their application for amplifier circuits, signal conditioning, switching functions and filters. In addition to dealing with typical electronic circuits found in common applications including group work and practical courses, students can deepen their knowledge of linear circuits based on non-linear components. Non-idealities of electronic circuits and design concepts (as the opposite of analysis) are also discussed. The course is a prerequisite for topics such as analog integrated circuits, RF circuits for wireless communication, A/D and D/A converters and optoelectronics, which are offered in higher semesters.
Content Getting to know and understanding basic transistor and op-amp circuits. Independent assembly and commissioning of simple circuits including power supply decoupling. Performing and understanding various basic measurement methods such as DC and AC analysis, measurements in the time and frequency domain, impedance measurements and measurement of transfer characteristics. In the practical course, the following topics and circuits are dealt with in more detail: characterization of a real capacity including non-idealities; Common Emitter Transistor Amplifier with Resistor Feedback; characterization of a real amplifier with non-idealities; basic amplifier circuits; bandpass filter with amplifiers, resistors and capacitances; A/D and D/A converters; Amplifier-based oscillator and function generator.

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
ECTS credits 1 CP
Test H. Wang
Form Ungraded semester performance
Language of examination English
Repetition Repetition is only possible after re-registering for the learning unit.
Additional information on the exam mode Condition for passing: active participation in 5 out of 6 internships.

4th Semester
COMPUTER ENGINEERING

Abstract The course provides knowledge on the inner working of computer systems by introducing basic concepts in the design of microprocessors and operating systems
Educational objective By the end of the course, the students should be able to analyze and think critically about the design and implementation of computer systems at the hardware and software boundary.
Content On the hardware side, the course will show how microprocessors implement control and data paths before introducing microarchitectural optimizations such as pipelining, speculation and caching. On the software side, the course will show how to program a microprocessor before introducing fundamental concepts in the design of operating systems such as on physical and virtual memory management, process management and scheduling.

The lectures are complemented by theoretical exercises and six practical assignments that cover the core concepts of the course and allow students to gain a deeper understanding of the topics.
Literature 1) D.A. Patterson, J.L. Hennessy: Computer Organization and Design RISC-V Edition: The Hardware Software Interface (2nd Edition), ISBN-13: 978-0128203316

2) K. Razavi: Kernel Construction on Modern Hardware, online book provided as part of the course.
Requirements / Special Programming skills in systems languages such as C or C++, knowledge of digital design.
CompetenciesCompetencies
Subject-specific skills Concepts and theories checked
Processes and technologies checked
Method-specific competencies Analytical skills checked
Decision-making promoted
Problem solving checked
Project management promoted
Social skills Communication promoted
Cooperation and teamwork promoted
Personal skills Customization and flexibility promoted
Creative thinking checked
Critical thinking checked

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Exam Block 2)
ECTS credits 4 CP
Test K. Razavi
Form Session Exam
Language of examination English
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode written 120 minutes
Additional information on the exam mode The final exam will cover the topics discussed in the class and the practical assignments. There are four practical assignments that upon successful completion can add up to 0.25 to the final grade.
Aids in writing No written aids or calculators allowed.
Digital Exam The exam takes place on equipment provided by ETH Zurich.
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

SIGNAL AND SYSTEMS THEORY II

Abstract Time-continuous and time-discrete linear system theory, state-space methods, frequency domain methods, controllability, observability, stability.
Educational objective Introduction to the basic concepts of systems theory
Content Modeling and Type Designation of Dynamic Systems.

Modeling of linear, time-invariant systems by equations of state. Solving equations of state by time-domain and Laplace domain methods. Stability, controllability and observability analysis. Description in the frequency domain, Bode and Nyquist diagram. Scanned and discrete time systems.

Further topics: Nonlinear Systems, Chaos, Discrete Event Systems, Hybrid Systems.
Script Copy of the slides
Literature Recommended:
K.J. Astrom and R. Murray, "Feedback Systems: An Introduction for Scientists and Engineers," Princeton University Press 2009

http://www.cds.caltech.edu/~murray/amwiki/

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Exam Block 2)
ECTS credits 4 CP
Test J. Lygeros
Form Session Exam
Language of examination English
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode written 120 minutes
Additional information on the exam mode Continuous performance assessment: Additional 0.25 grade points can be obtained during the semester through (optional) quiz exercises.
Aids in writing Students will be allowed to bring to the examination one A4 sized sheet of paper (two sided) with handwritten notes.
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

NUMERICAL METHODS

Abstract This course gives an introduction to numerical methods. Methods of analysis (zero search of functions, integration) and ordinary
differential equations are covered. The focus is on the acquisition of skills in the application of numerical methods.
Educational objective The students of the lecture should learn, understand, assess, implement and apply basic numerical methods that are important for computational methods in engineering. The focus of the lecture is on the numerical solution of ordinary differential equations. In addition, they are to be familiarized with important concepts and techniques of numerical mathematics. They should be enabled to select suitable numerical methods for a problem in a targeted manner and, if necessary, to adapt them to the problem.
Content Quadrature, Newton method, initial value problems of ordinary differential equations: explicit one-step methods, step size control, stability analysis and implicit methods, structure-preserving methods
Script On the lecture website, the lecture notes, slides and the resulting script as well as other relevant links will be available.
Literature The reading list will be announced during the lecture and on the lecture's website.
Requirements / Special Solid knowledge of analysis (approximation and vector analysis: grad, div, curl) and linear algebra (Gauss elimination, matrix decompositions, as well as algorithms, vector and matrix calculus: matrix multiplication, determinant, LU decomposition of non-singular matrices, singular value decomposition) are expected.
CompetenciesCompetencies
Subject-specific skills Concepts and theories checked
Processes and technologies promoted
Method-specific competencies Analytical skills checked
Decision-making checked
Media and digital technologies promoted
Problem solving checked
Social skills Communication promoted
Cooperation and teamwork promoted
Personal skills Creative thinking checked
Critical thinking checked

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Exam block 3)
Bachelor's degree program Materials Science 2017; Issue 28.01.2020 (Exam Block 4)
ECTS credits 4 CP
Test V. C. Gradinaru

Form Session Exam
Language of examination German
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode written 180 minutes
Additional information on the exam mode
Bonus of 0.25 points for students earning more than 75% of the moodle quizzes
during every week of the teaching period,
Aids in writing No aids.
Digital Exam The exam takes place on equipment provided by ETH Zurich.
Remote Testing It is not possible to take it as a remote examination.
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

ELECTROMAGNETIC FIELDS AND WAVES

Abstract The subject of this lecture is the generation and propagation of electromagnetic fields. Starting from Maxwell's equations, the wave equation and its solutions are derived. Specific topics are: fields in free space, refraction and reflection at interfaces, dipole radiation and field angle spectrum.
Educational objective Understanding of electromagnetic fields and areas of application

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Exam block 3)
ECTS credits 4 CP
Test L. Novotny
Form Session Exam
Language of examination German
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode written 120 minutes
Additional information on the exam mode All homework is collected electronically via Moodle. Of these, 3 randomly selected series will be evaluated. If on average more than 70% of the maximum points are achieved in these 3 series, the grade of the block exam will be increased by 0.25. At the end of the semester, it will be announced which series will be included in the evaluation.
Aids in writing 3 A4 sheets written on both sides. No other aids (calculators, computers, mobile phones, ..).
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

SEMICONDUCTOR DEVICES

Abstract The course covers the basic principles of semiconductor devices in micro-, opto-, and power electronics. It imparts knowledge both of the basic physics and on the operation principles of pn-junctions, diodes, contacts, bipolar transistors, MOS devices, solar cells, photodetectors, LEDs and laser diodes.
Learning objective Understanding of the basic principles of semiconductor devices in micro-, opto-, and power electronics.
Content Brief survey of the history of microelectronics.
Basic physics: Crystal structure of solids, properties of silicon and other semiconductors, principles of quantum mechanics, band model, conductivity, dispersion relation, equilibrium statistics, transport equations, generation-recombination (G-R), Quasi-Fermi levels.
Physical and electrical properties of the pn-junction. pn-diode: Characteristics, small-signal behaviour, G-R currents, ideality factor, junction breakdown.
MOS devices: Band diagram, MOSFET operation, CV- and IV characteristics, frequency limitations and non-ideal behaviour.
Bipolar transistor: Operation principles, modes of operation, characteristics, models, simulation.
Lecture notes Lecture slides.
Literature The course follows the book Modern Semiconductor Devices for Integrated Circuits by Chenming Hu.
More detailed book: Neamen, Semiconductor Physics and Devices, ISBN 978-007-108902-9, Fr. 89.00
Prerequisites / Notice Qualifications: Physics I+II
CompetenciesCompetencies

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

Self-direction and Self-management fostered

Performance assessment
Performance assessment information (valid until the course unit is held again)
Performance assessment as a semester course
In examination block for Bachelor's Degree Programme in Electrical Engineering and Information Technology 2017; Version 07.11.2024 (Examination Block 3)
ECTS credits 4 credits
Examiners C. Bolognesi, T. Popovic
Type session examination
Language of examination English
Repetition The performance assessment is offered every session. Repetition possible without re-enrolling for the course unit.
Mode of examination written 180 minutes
Additional information on mode of examination An optional midterm exam (organized if the current epidemiological situation allows) counts for 25% of the final grade if this improves the final grade.

Participation to the exercise sessions is rewarded with up to 0.25 points in the sense of the learning elements. Important: It is expected that you attend the sessions and solve the exercises. To assess your participation optional short tests (~15 min) will be implemented via moodle during the exercise sessions. Tests will have simple questions that check the material concepts, and will be organized on four random dates. Those who satisfactorily solved at least 3 tests (out of 4) will receive a 0.25 grade point credit.
Written aids Lecture Slides and Exercise Slides, Exercise Problems with solutions; Student's course summary (unlimited number of pages); Pocket calculator (Taschenrechner) with no communication capabilities.
If the course unit is part of an examination block, the credits are allocated for the successful completion of the whole block.
This information can be updated until the beginning of the semester; information on the examination timetable is binding.

PROBABILITY THEORY AND STATISTICS

Abstract Probability Models and Applications, Introduction to Estimation Theory and Statistical Test Theory
Educational objective Ability to understand and apply the probabilistic methods and models covered. Ability to perform simple statistical tests on your own and interpret the results
Content The concept of probability space and some classical models: axioms of Kolmogorov, simple inferences, discrete models, density functions, product models, relationship between the models considered so far, distribution functions, transformation of probability distributions. Conditional probabilities: definition and examples, calculation of absolute from conditional probabilities, Bayes' rule, application to news sources, conditional distributions. Expected value of a random variable, variance, covariance and correlation, linear forecasts, law of large numbers, central limit theorem. Introduction to statistics: estimation of parameters, tests
Script yes
Literature Textbook: P. Brémaud: 'An Introduction to Probabilistic Modeling', Springer, 1988
CompetenciesCompetencies
Subject-specific skills Concepts and theories checked
Processes and technologies checked
Method-specific competencies Analytical skills checked
Decision-making promoted
Problem solving checked
Social skills Communication promoted
Cooperation and teamwork promoted
Personal skills Customization and flexibility checked
Creative thinking checked
Critical thinking promoted
Integrity and Work Ethic promoted

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
In the examination block for Bachelor's degree programme in Electrical Engineering and Information Technology 2017; Issue 07.11.2024 (Examination block 3)
Bachelor's degree programme in Computational Sciences 2018; Issue 07.11.2024 (Examination block G3)
ECTS credits 4 CP
Test J. Teichmann, P. Harms
Form Session Exam
Language of examination German
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode 90 minutes in writing

Aids in writing Written aids: 5 A4 sheets, written on both sides, written or printed by hand (font size at least 11 points), no calculators.
If the course unit is examined within an examination block, the credit points are awarded for the entire passed block.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

5th Semester
COMPUTATIONAL THINKING

Abstract We learn: algorithmic principles, dynamic and linear programming, complexity, P vs. NP, approximation, reductions, cryptography, zero-knowledge proofs, relational databases, SQL, machine learning, regression, gradient descent, decision trees, deep neural networks, universal approximation, advanced layers and architectures, reinforcement learning, Turing machines, computability, and more.
Learning objective Computation is everywhere, but what is computation actually? In this lecture we will discuss the power and limitations of computation. Computational thinking is about understanding machine intelligence: What is computable, and how efficiently?

Understanding computation lies at the heart of many exciting scientific, social and even philosophical developments. Computational thinking is more than programming a computer, it means thinking in abstractions. Consequently, computational thinking has become a fundamental skill for everyone, not just computer scientists. For example, functions which can easily be computed but not inverted are at the heart of understanding data security and privacy. The design of efficient electronic circuits is related to computational complexity. Machine learning on the other hand has given us fascinating new tools to teach machines how to estimate functions. Thanks to clever heuristics, machines now appear to be capable of solving complex cognitive tasks. In this class, we study various problems together with the fundamental theory of computation.

The course uses Python as a programming language. Python is popular and intuitive, a programming language that looks and feels a bit like human instructions. The lecture will feature weekly exercises.

This course follows the flipped classroom paradigm. Students will self-study all important concepts by reading a chapter in the script, and by watching a few short video clips. The class meets every two weeks to answer questions, and for a quiz on the current topic.
Content Computation is everywhere, but what is computation actually? In this lecture we will discuss the power and limitations of computation. Computational thinking is about understanding machine intelligence: What is computable, and how efficiently?

Understanding computation lies at the heart of many exciting scientific, social and even philosophical developments. Computational thinking is more than programming a computer, it means thinking in abstractions. Consequently, computational thinking has become a fundamental skill for everyone, not just computer scientists. For example, functions which can easily be computed but not inverted are at the heart of understanding data security and privacy. The design of efficient electronic circuits is related to computational complexity. Machine learning on the other hand has given us fascinating new tools to teach machines how to estimate functions. Thanks to clever heuristics, machines now appear to be capable of solving complex cognitive tasks. In this class, we study various problems together with the fundamental theory of computation.

The course uses Python as a programming language. Python is popular and intuitive, a programming language that looks and feels a bit like human instructions. The lecture will feature weekly exercises.

This course follows the flipped classroom paradigm. Students will self-study all important concepts by reading a chapter in the script, and by watching a few short video clips. The class meets every two weeks to answer questions, and for a quiz on the current topic.
Lecture notes The script is available here: https://disco.ethz.ch/courses/coti/
Prerequisites / Notice This class is suitable for students who have a basic understanding of programming.

For additional Python programming experience we recommend attending the CodeJam lab: https://disco.ethz.ch/courses/codejam/

For practical deep learning exerience we recommend attending the HODL lab: https://disco.ethz.ch/courses/hodl/
CompetenciesCompetencies
Subject-specific Competencies Concepts and Theories assessed
Techniques and Technologies assessed
Method-specific Competencies Analytical Competencies assessed
Decision-making fostered
Media and Digital Technologies assessed
Problem-solving assessed
Social Competencies Communication fostered
Personal Competencies Adaptability and Flexibility assessed
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Performance assessment
Performance assessment information (valid until the course unit is held again)
Performance assessment as a semester course
ECTS credits 4 credits
Examiners R. Wattenhofer
Type session examination
Language of examination English
Repetition The performance assessment is offered every session. Repetition possible without re-enrolling for the course unit.
Mode of examination written 120 minutes

Additional information on mode of examination Students can earn a 0.25 grade bonus for the exam, by correctly answering at least half the questions in the quizzes throughout the semester.
Written aids open book
This information can be updated until the beginning of the semester; information on the examination timetable is binding.

HIGH-FREQUENCY DESIGN TECHNIQUES

Abstract Introduction to the basics of high-frequency circuit design techniques used in the realization of high-bandwidth communication systems and devices. Modern society depends on increasingly large data masses that need to be transmitted/processed as rapidly as possible: higher carrier frequencies allow wider bandwidth channels which enable higher data transmission rates.

Learning objective Familiarize students with the essential tools and principles exploited in the high-frequency design. Introduction to circuit simulation. Introduction to amplifier design.

Content Introduction to wireless, radio spectrum. Review of vectors and complex numbers, AC circuit analysis, matching networks, distributed circuit design, transmission lines and transmission line equations, reflection coefficients, the Smith Chart and its software, voltage standing wave ratio (VSWR), skin effect, matrix analysis, scattering parameters, electromagnetic fields and waves, amplifier design.

Hands-on experience with mesurement equipement.

Lecture notes A detailed script is provided for each lecture, including the exercises and their solutions.

Literature Textbook: High Frequency Techniques, by Joseph F. White, 2004, Wiley-Interscience & IEEE Press ISBN 0-471-45591-1 (free online access via ETH-Bibliothek)

CompetenciesCompetencies

Subject-specific Competencies	Concepts and Theories	assessed
	Techniques and Technologies	assessed
Method-specific Competencies	Analytical Competencies	assessed
	Problem-solving	assessed
Social Competencies	Communication	fostered
	Cooperation and Teamwork	assessed
Personal Competencies	Creative Thinking	assessed
	Critical Thinking	assessed

Performance assessment

Performance assessment information (valid until the course unit is held again)

Performance assessment as a semester course

ECTS credits 4 credits

Examiners C. Bolognesi, T. Popovic

Type session examination

Language of examination English

Repetition The performance assessment is offered every session. Repetition possible without re-enrolling for the course unit.

Mode of examination written 180 minutes

Additional information on mode of examination An optional written midterm exam will be organized mid semester during lecture hours, which will count for 30% of the final grade if it improves it.

Participation to the exercise sessions is rewarded with up to 0.25 points in the sense of completing the learning tasks. Important: It is expected that you attend the sessions and participate in inverted classroom group activities which will be organized several times during the semester. Those who satisfactorily fulfill the tasks will receive a 0.25 grade point credit.
Written aids Course summary with total 20 sheets of paper, both sides (40 pages), and calculator with no communication capabilities.
This information can be updated until the beginning of the semester; information on the examination timetable is binding.

INTRODUCTION TO ELECTRIC POWER TRANSMISSION: SYSTEM & TECHNOLOGY

Abstract Introduction to theory and technology of electric power transmission systems.
Educational objective At the end of this course, the student will be able to: describe the structure of electric power systems, name the most important components and describe what they are needed for, apply models for transformers and overhead power lines, explain the technology of lines, know about electrical safety, calculate electric withstand strength of gas gaps, stationary power flows and other basic parameters in simple power systems.
Content Structure of electric power systems, transformer and power line models, analysis of and power flow calculation in basic systems, technology and principle of electric power systems.
Script Lecture script in English, exercises and sample solutions.
CompetenciesCompetencies
Subject-specific skills Concepts and theories checked
Processes and technologies checked
Method-specific competencies Analytical skills promoted
Decision-making promoted
Media and digital technologies promoted
Problem solving promoted
Project management promoted
Social skills Communication promoted
Cooperation and teamwork promoted
Customer orientation promoted
Leadership and responsibility promoted
Self-portrayal and social influence promoted
Sensitivity to diversity promoted
Negotiation promoted
Personal skills Customization and flexibility promoted
Creative thinking promoted
Critical thinking promoted
Integrity and Work Ethic promoted
Self-confidence and self-reflection promoted
Self-control and self-management promoted

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
ECTS credits 4 CP
Test C. Franck, G. Hug
Form Session Exam
Language of examination English
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.

Examination mode written 180 minutes
Aids in writing 2 DIN-A4 pages (1 sheet of paper), calculator w/o communication capability
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

6th Semester
COMMUNICATION AND DETECTION THEORY

Abstract This course teaches the foundations of modern digital communications and detection theory. Topics include the geometry of the space of energy-limited signals; the baseband representation of passband signals, spectral efficiency and the Nyquist Criterion; the power and power spectral density of PAM and QAM; hypothesis testing; Gaussian stochastic processes; and detection in white Gaussian noise.
Educational objective This is an introductory class to the field of wired and wireless communication. It offers a glimpse at classical analog modulation (AM, FM), but mainly focuses on aspects of modern digital communication, including modulation schemes, spectral efficiency, power budget analysis, block and convolu- tional codes, receiver design, and multi- accessing schemes such as TDMA, FDMA and Spread Spectrum.
Content - Baseband representation of passband signals.
- Bandwidth and inner products in baseband and passband.
- The geometry of the space of energy-limited signals.
- The Sampling Theorem as an orthonormal expansion.
- Sampling passband signals.
- Pulse Amplitude Modulation (PAM): energy, power, and power spectral density.
- Nyquist Pulses.
- Quadrature Amplitude Modulation (QAM).
- Hypothesis testing.
- The Bhattacharyya Bound.
- The multivariate Gaussian distribution
- Gaussian stochastic processes.
- Detection in white Gaussian noise.
Script n/a
Literature A. Lapidoth, A Foundation in Digital Communication, Cambridge University Press, 2nd edition (2017)

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
ECTS credits 6 CP
Test A. Lapidoth
Form Session Exam
Language of examination English
Repetition The performance assessment is only offered in the session after the learning unit. Repetition is only possible after re-registration.
Examination mode written 180 minutes
Aids in writing Hardcopies of the course textbook, course handouts, and personal notes.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

RADIO-FREQUENCY ELECTRONICS I

Abstract Electronics for communications systems, with emphasis on realization. Low noise amplifiers, modulators and demodulators, transmit amplifiers and oscillators are discussed in the context of wireless communications. Wireless receiver, transmitter and frequency synthesizer will be described. Importance of and trade offs among sensitivity, linearity and selectivity are discussed extensively.

Learning objective Foundation course for understanding modern electronic circuits for communication applications. We learn how theoretical communications principles are reduced to practice using transistors, switches, inductors, capacitors and resistors. The harsh environment such communication electronics will be exposed to and the resulting requirements on the sensitivity, linearity and selectivity help explain the design trade offs encountered in every circuit block found in a modern transceiver.

Content Accounting for more than two trillion dollars per year, communications is one of the most important drivers for advanced economies of our time. Wired networks have been a key enabler to the internet age and the proliferation of search engines, social networks and electronic commerce, whereas wireless communications, cellular networks in particular, have liberated people and increased productivity in developed and developing nations alike. Integrated circuits that make such communications devices light weight and affordable have played a key role in the proliferation of communications.

This course introduces our students to the key components that realize the tangible products in electronic form. We begin with an introduction to wireless communications, and describe the harsh environment in which a transceiver has to work reliably. In this context we highlight the importance of sensitivity or low noise, linearity, selectivity, power consumption and cost, that are all vital to a competitive device in such applications.

We shall review bipolar and MOS devices from a designer's prospectives, before discussing basic amplifier structures - common emitter/source, common base/gate configurations, their noise performance and linearity, impedance matching, and many other things one needs to know about a low noise amplifier.

We will discuss modulation, and the mixer that enables its implementation. Noise and linearity form an inseparable part of the discussion of its design, but we also introduce the concept of quadrature demodulator, image rejection, and the effects of mismatch on performance.

When mixers are used as a modulator the signals they receive are usually large and the natural linearity of transistors becomes insufficient. The concept of feedback will be introduced and its function as an improver of linearity studied in detail.

Amplifiers in the transmit path are necessary to boost the power level before the signal leaves an integrated circuit to drive an even more powerful amplifier (PA) off chip. Linearized pre-amplifiers will be studied as part of the transmitter.

A crucial part of a mobile transceiver terminal is the generation of local oscillator signals at the desired frequencies that are required for modulation and demodulation. Oscillators will be studied, starting from stability criteria of an electronic system, then leading to criteria for controlled instability or oscillation. Oscillator design will be discussed in detail, including that of crystal controlled oscillators which provide accurate time base.

An introduction to phase-locked loops will be made, illustrating how it links a variable frequency oscillator to a very stable fixed frequency crystal oscillator, and how phase detector, charge pump and programmable dividers all serve to realize an agile frequency synthesizer that is very stable in each frequency synthesized.
Lecture notes Script is available online under
https://iis-students.ee.ethz.ch/lectures/communication-electronics/
Prerequisites / Notice The course Analog Integrated Circuits is recommended as preparation for this course.

Performance assessment
Performance assessment information (valid until the course unit is held again)
Performance assessment as a semester course
ECTS credits 6 credits
Examiners H. Wang
Type session examination
Language of examination English
Repetition The performance assessment is only offered in the session after the course unit. Repetition only possible after re-enrolling.
Mode of examination written 180 minutes
Written aids 10 Seiten handschrifltliche oder maschinengeschriebene Zusammenfassung, Taschenrechner ohne Kommunikationsmöglichkeiten.
This information can be updated until the beginning of the semester; information on the examination timetable is binding.

HIGH-SPEED SIGNAL PROPAGATION

Abstract Understanding of high-speed signal propagation in microwave cables and integrated circuits and printed circuit boards.

As clock frequencies rise in the GHz domain, there is a need grasp signal propagation to maintain good signal integrity in the face of symbol interference and cross-talk.

The course is of high value to all interested in high-speed analog (RF, microwave) or digital systems.
Learning objective Understanding of high-speed signal propagation in interconnects, microwave cables and integrated transmission lines such as microwave integrated circuits and/or printed circuit boards.

As system clock frequencies continuously rise in the GHz domain, a need urgently develops to understand high-speed signal propagation in order to maintain good signal integrity in the face of phenomena such as inter-symbol interference (ISI) and cross-talk.

Concepts such as Scattering parameters (or S-parameters) are key to the characterization of networks over wide bandwidths. At high frequencies, all structures effectively become "transmission lines." Unless care is taken, it is highly probable that one ends-up with a bad transmission line that causes the designed system to malfunction.

Filters will also be considered because it turns out that some of the problems associated by lossy transmission channels (lines, cables, etc) can be corrected by adequate filtering in a process called "equalization."
Content Transmission line equations of the lossless and lossy TEM-transmission line. Introduction of current and voltage waves. Representation of reflections in the time and frequency domain. Application of the Smith chart. Behavior of low-loss transmission lines. Attenuation and impulse distortion due to skin effect. Transmission line equivalent circuits. Group delay and signal dispersion. Coupled transmission lines. Scattering parameters. Butterworth-, Chebychev- and Bessel filter approximations: filter synthesis from low-pass filter prototypes.
Lecture notes Skript: Leitungen und Filter (DE)
Lecture notes in English
Exercise slides and problems in English
Literature David M. Pozar, Microwave Engineering
CompetenciesCompetencies

Subject-specific Competencies	Concepts and Theories	assessed
Techniques and Technologies	assessed	
Method-specific Competencies	Analytical Competencies	assessed
Decision-making	fostered	
Media and Digital Technologies	fostered	
Problem-solving	assessed	

Project Management fostered
Social Competencies Communication assessed
Cooperation and Teamwork assessed
Customer Orientation fostered
Leadership and Responsibility fostered
Self-presentation and Social Influence fostered
Sensitivity to Diversity fostered
Negotiation fostered
Personal Competencies Adaptability and Flexibility fostered
Creative Thinking assessed
Critical Thinking assessed
Integrity and Work Ethics fostered
Self-awareness and Self-reflection fostered
Self-direction and Self-management fostered

Performance assessment
Performance assessment information (valid until the course unit is held again)
Performance assessment as a semester course
ECTS credits 6 credits
Examiners C. Bolognesi, T. Popovic
Type session examination
Language of examination English
Repetition The performance assessment is only offered in the session after the course unit. Repetition only possible after re-enrolling.
Mode of examination written 180 minutes
Additional information on mode of examination A noncompulsory oral midterm exam will be organized around the middle of the semester which will count for 30% of the final grade (if it improves it). This midterm exam will be focused mostly on practical projects (such as design and implementation of simple RF circuits) that students can do during the first half of the semester. Students that participate in practical projects will also get an opportunity to measure their final fabricated circuits in our lab.
Participation to the exercise sessions is rewarded with 0.25 points in the sense of the learning elements. Important: It is expected that students solve the exercises on a regular basis. As an incentive, student exercise solutions will be collected on 3 random dates. Those who satisfactorily solved at least 2 exercise sets will receive a 0.25 grade point credit.
Written aids Lecture notes, exercise slides and solutions, lecture summary (unlimited number of pages), course script, pocket calculator, ruler and compass.
This information can be updated until the beginning of the semester; information on the examination timetable is binding.

MEASUREMENT AND TESTING TECHNOLOGY

Abstract Introduction to testing and measurement technology, as it is the basis in all areas of engineering. The lecture is strongly practice- and application-oriented, and includes several practical experiments. The content "Measurement and Testing Technology" is relevant for all specialist areas of electrical engineering and is introduced using examples from various areas.
Educational objective At the end of the lecture, students will be able to:
• Perform basic electrical experiments and collect measurement data, especially with the oscilloscope.
• Maintain a meaningful measurement report, create a clear test protocol and estimate the measurement accuracy of the experiment.
• describe and apply basic causes of electromagnetic interference as well as methods for avoidance, reduction or shielding.
• explain and apply various methods for the generation and measurement of (high) voltages, as well as calculate the corresponding quantities.
Content - Measurement technology, measurement uncertainty, measurement protocols
- Generation and measurement of high voltages
- Electromagnetic compatibility
- Laboratory practicals
Script Course Notes
Literature J. Hoffmann, Taschenbuch der Messtechnik, Carl Hanser Verlag, 7th edition, 2015 (ISBN: 978-3446442719)
A. Schwab, Electromagnetic Compatibility, Springer Verlag, 6th edition, 2010 (ISBN: 978-3642166099)
CompetenciesCompetencies
Subject-specific skills Concepts and theories checked
Processes and technologies checked
Method-specific competencies Analytical skills checked
Decision-making checked
Media and digital technologies promoted
Problem solving checked
Project management promoted
Social skills Communication promoted
Cooperation and teamwork checked
Customer orientation promoted
Leadership and responsibility promoted
Self-portrayal and social influence promoted
Sensitivity to diversity promoted
Negotiation promoted
Personal skills Customization and flexibility promoted
Creative thinking checked
Critical thinking checked
Integrity and Work Ethic promoted

Self-confidence and self-reflection promoted
Self-control and self-management promoted

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
ECTS credits 6 CP
Test C. Franck, P. Simka
Form Session Exam
Language of examination German
Repetition The performance assessment is only offered in the session after the learning unit. Repetition is only possible after re-registration.
Examination mode 90 minutes in writing
Additional information on the exam mode The grade is made up of 50% of the grading of the written and mandatory test protocols and 50% of the written examination.

Please note: Students who have already taken this course one year earlier but did not register for the exam can choose whether their existing performance elements will be credited or whether they will take them for the first time. To this end, the students concerned should consult with the examiners.
Aids in writing Handwritten summary, max. 2 sheets (=4 DINA4 pages). Calculator without means of communication and no saved pdf files.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

COMMUNICATION NETWORKS

Abstract At the end of this course, you will understand the fundamental concepts behind communication networks and the Internet. Specifically, you will be able to:

- understand how the Internet works;
- build and operate Internet-like infrastructures;
- identify the right set of metrics to evaluate the performance of a network and propose ways to improve it.

Educational objective At the end of the course, the students will understand the fundamental concepts of communication networks and Internet-based communications. Specifically, students will be able to:

- understand how the Internet works;
- build and operate Internet-like network infrastructures;
- identify the right set of metrics to evaluate the performance or the adequacy of a network and propose ways to improve it (if any).

The course will introduce the relevant mechanisms used in today's networks both from an abstract perspective but also from a practical one by presenting many real-world examples and through multiple hands-on projects.

For more information about the lecture, please visit: https://comm-net.ethz.ch

Script Lecture notes and material for the course will be available before each course on: https://comm-net.ethz.ch

Literature Most of course follows the textbook "Computer Networking: A Top-Down Approach (6th Edition)" by Kurose and Ross.

Requirements / Special No prior networking background is needed. The course will include some programming assignments (in Python) for which the material covered in Technische Informatik 1 (227-0013-00L) will be useful.

Assessment

Information on performance assessment (valid until the course unit is reread)

Performance assessment as a semester course

ECTS credits 6 CP

Test L. Vanbever

Form Session Exam

Language of examination English

Repetition The performance assessment is only offered in the session after the learning unit. Repetition is only possible after re-registration.

Examination mode 150 minutes in writing

Additional information on the exam mode 70% of the final grade will be based on the final (written) exam, while the remaining 30% will be based on continuous performance

assessments. The continuous performance assessments will consist in two graded group projects. The first one (centered on 'Internet routing') will take place around the middle of the semester. The second one (centered on 'reliable transport') will take place towards the end of the semester. The first project will count for 20% of the final grade, while the second will count for 10% of the final grade. If a student does not submit a project or does not contribute to the group work, he/she will receive a grade of 1.0 for the corresponding project. Students repeating the course can decide at the beginning of the semester if they want to keep the previous grades of their continuous performance assessments.
Aids in writing All written material (books, notes, lab exercises etc.) is allowed; all electronic devices are prohibited, except for (non-connected) calculators.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

OPTICS AND PHOTONICS

Abstract This lecture covers both - the fundamentals of "Optics" such as e.g. "ray optics", "coherence", the "Planck law", the "reciprocity theorem" or the "Einstein relations" but also the fundamentals of "Photonics" on the generation (the laser), processing, transmission and detection of photons.
Educational objective A sound base for work in the field of optics and photonics will be conveyed. Key principles of optics will the thaught. The lecture passes on the essentials for work with free-space optics, fiber or waveguide optics. In addition, important optical devices will be discussed. Among them are e.g. optical filters, copulers (MMI-couplers,...), Holograms,... .
Content Chapter 1: Ray Optics
Chapter 2: Electromagnetic Optics
Chapter 3: Polarization
Chapter 4: Coherence and Interference
Chapter 5: Fourier Optics and Diffraction
Chapter 6: Guided Wave Optics
Chapter 7: Optical Fibers
Chapter 8: The Laser
Script Lecture notes will be handed out.
Requirements / Special Fundamentals of Electromagnetic Fields (Maxwell Equations) & Bachelor Lectures on Physics.
CompetenciesCompetencies
Subject-specific skills Concepts and theories checked
Processes and technologies checked
Method-specific competencies Analytical skills promoted
Problem solving promoted

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
ECTS credits 6 CP
Test J. Leuthold
Form Session Exam
Language of examination English
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode oral 30 minutes
Additional information on the exam mode Participation in the practice is rewarded with up to 0.25 grade points in terms of the learning elements. The exercises are expected to be solved. For control, the exercises will be held on 3 random dates. If you have solved at least 2 exercise series, you will receive 0.25 grade point credits.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

FUNDAMENTALS OF COMPUTER ARCHITECTURE

Abstract Computer architecture is the science & art of designing and optimizing hardware components and the hardware/software interface to create a computer that meets design goals. This course covers modern processors architectures, state-of-the-art accelerators (e.g., GPUs, systolic arrays, ML accelerators), memory systems (caches, main memory, storage), with a focus on both fundamentals and research.
Learning objective The major goal of this course is to equip students with the knowledge of the hardware architectures and hardware/software interfaces of modern computing platforms, including how they are designed and optimized, so that students can learn tradeoffs in design and how to make and evaluate such tradeoffs. A secondary goal is to equip students with the capability to do research and development in computer architecture. We aim to cover components of modern high-performance processor architectures (e.g., superscalar, multi-threaded, out-of-order, VLIW), state-of-the-art accelerators (e.g., systolic arrays, GPUs, data-centric architectures) for data-intensive applications (e.g., machine learning, graph analytics, bioinformatics), and memory systems (e.g., main memory, storage, and emerging memory technologies), etc. We will focus on fundamentals as well as cutting-edge research.
Content The principles presented in the lecture are reinforced in the laboratory exercises using state-of-the-art research simulators and frameworks (e.g., Ramulator 2.0, MQSim, DRAM Bender) for more in-depth understanding of specific system components (e.g., processor, memory scheduling, prefetching, storage subsystem, memory controller, DRAM chips)
Lecture notes All the materials (including lecture slides) will be provided on the course website: https://safari.ethz.ch/foca/

Lectures will be livestreamed and are available to watch at anytime on YouTube.
Literature We will provide required and recommended readings in every lecture. They will mainly consist of research papers presented in major Computer Architecture and related conferences and journals.

Performance assessment
Performance assessment information (valid until the course unit is held again)
Performance assessment as a semester course
ECTS credits 6 credits
Examiners O. Mutlu, S. Sadrosadati
Type session examination
Language of examination English
Repetition The performance assessment is only offered in the session after the course unit. Repetition only possible after re-enrolling.
Mode of examination written 180 minutes
Additional information on mode of examination One exam of 180 min (50%).
Lab assignments with submission and face-to-face interviews (50%).

Only one exam in session exam (August). No extra mid-session revision is possible for this course.
No books, papers, computers, phones, calculators or other electronic devices are allowed.
Maximum 5 A4 hand-written pages with notes are allowed for the exam.
Written aids None
This information can be updated until the beginning of the semester; information on the examination timetable is binding.

POWER SEMICONDUCTORS

Abstract Power semiconductor devices are the core of today's energy efficient electronics. In this course, an understanding of the functionality of modern power devices is developed. Typical device concepts for power rectifiers and transistors are discussed. In addition to silicon-based devices, wide bandgap semiconductors such as silicon carbide (SiC) and gallium nitride (GaN) are considered.
Educational objective The goal of this course is to develop an understanding of modern power device concepts. After following the course, the student will be able to choose a power device for an application, know the basic functionality, and is able to describe the performance and reliability related building blocks of the device design. Furthermore, the student will have an understanding of current and future developments in power devices.
Content • Basic semiconductor physics concepts
• Device design/conceptual thinking
• Device simulation (TCAD)
• Device processing
• Diodes
• BJT and JFET
• Thyristor
• MOSFET and power MOSFET
• IGBT and HEMT
• Packaging and Applications
Script Script will be made available via Moodle, printouts of the slides will be distributed during the lectures.
Literature The course follows a collection of different books; more details are being listed in the script.
Requirements / Special Lectures Semiconductor Components, Power Electronics

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
ECTS credits 6 CP
Test U. Grossner, M. Belanche Guadas, H. Goncalves de Medeiros, P. Natzke
Form Session Exam
Language of examination English
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode written 180 minutes
Additional information on the exam mode In addition to the final grade, a maximum bonus of 0.25 can be obtained as follows:
- 0.10 for a quiz on Moodle,
- 0.15 for a laboratory report.

Aids in writing Personal summary (max. 2 A4 pages, single-sided), non-programmable calculator or calculator in exam mode, no communication devices.
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

FUNDAMENTALS OF PHYSICAL MODELING AND SIMULATIONS

Abstract Mathematical description of different physical phenomena and numerical methods for solving the obtained equations are discussed. The course presents the fundamentals of mathematical modeling including ordinary and partial differential equations along with boundary and initial conditions. Finite Difference Method and Finite Element Method for solving boundary value problems are shown in detail.
Educational objective After completing this course, a student will understand the main idea of representing physical phenomena with mathematical equations, will be able to apply an appropriate numerical method for solving the obtained equations, and will possess the knowledge to qualitatively evaluate the obtained results.
Content a. Introduction to physical modeling and simulations
b. Numerical methods for solving boundary (initial) value problems
b.i. Finite difference method (FDM)
b.ii. Finite element method (FEM)
c. Boundary (initial) value problems of different physical phenomena
c.i. Static and dynamic electric current distribution in solid conductors
c.ii. Static and dynamic electric charge transport in semiconductors
c.iii. Induced eddy currents in low frequency range (with numerous examples from the area of electrical energy technology)
c.iv. Wave propagation in the RF-, microwave-, and optical frequency range (with numerous examples relevant for communication technology)
c.v. Static and dynamic temperature distribution in solid bodies (with numerous examples relevant for electrical energy technology)
c.vi. Static and dynamic mechanical structural analysis (with numerous examples from the area of MEMS technology)
Script Lecture notes, Matlab programs, exercises and their solutions will be handed out.
Literature J. Smajic, "How To Perform Electromagnetic Finite Element Analysis", The International Association for the Engineering Modelling, Analysis & Simulation Community (NAFEMS), NAFEMS Ltd., Hamilton, UK, 2016.
Requirements / Special Fundamentals of Electromagnetic Fields, and Bachelor Lectures on Physics.

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
ECTS credits 6 CP
Test J. Smajic
Form Session Exam
Language of examination English
Repetition The performance assessment is offered in every session. Repetition is possible without having to re-register for the learning unit.
Examination mode written 120 minutes

Aids in writing Open book exam + Calculator
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.

NEURAL SYSTEMS

Abstract This course introduces principles of information processing in neural systems. It covers basic neuroscience for engineering students, experiment techniques used in animal research and methods for inferring neural mechanisms. Students learn about neural information processing and basic principles of natural intelligence and their impact on artificially intelligent systems.
Educational objective This course introduces
- Basic neurophysiology and mathematical descriptions of neurons
- Methods for dissecting animal behavior
- Neural recordings in intact nervous systems and information decoding principles
- Methods for manipulating the state and activity in selective neuron types
- Neuromodulatory systems and their computational roles
- Reward circuits and reinforcement learning
- Imaging methods for reconstructing the synaptic networks among neurons
- Birdsong and language
- Neurobiological principles for machine learning.

Content From active membranes to propagation of action potentials. From synaptic physiology to synaptic learning rules. From receptive fields to neural population decoding. From fluorescence imaging to connectomics. Methods for reading and manipulation neural ensembles. From classical conditioning to reinforcement learning. From the visual system to deep convolutional networks. Brain architectures for learning and memory. From birdsong to computational linguistics.
Requirements / Special Before taking this course, students are encouraged to complete "Bioelectronics and Biosensors" (227-0393-10L).

As part of the exercises for this class, students are expected to complete a programming or literature review project to be defined at the beginning of the semester.

Assessment
Information on performance assessment (valid until the course unit is reread)
Performance assessment as a semester course
ECTS credits 6 CP
Test M. F. Yanik, B. Grewe
Form Session Exam
Language of examination English
Repetition The performance assessment is only offered in the session after the learning unit. Repetition is only possible after re-registration.
Examination mode written 120 minutes
Additional information on the exam mode The student's final grade is determined by a weighted average: 75% from the written exam grade and 25% from the project/exercise grade (compulsory continuous performance assessment).

The project/exercises will be graded individually. If no project/exercise is submitted, this will result in a grade of 1. The total project/exercise grade for the course will comprise a weighted average, i.e. if a project or an exercise spans two lectures it will be weighted double. Students repeating the course can decide at the beginning of the semester if they want to keep the previous grade of their continuous performance assessment (project& exercises).
Aids in writing none (closed book exam)
This information can be updated at the beginning of the semester; the information on the examination schedule is binding.