TUHH
Hamburg
University of
Technology

Module Manual

Bachelor of Science (B.Sc.)

Electrical Engineering

Cohort: Winter Term 2022

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Program description

Content

The electrical industry is the second largest industrial sector in Germany after mechanical engineering in terms of the number of employees. With approx. 847,000 employees, a turnover of approx. 179 billion euros is achieved (based on the year 2016, source: de.statista.com). Electrical engineering is thus not only one of the "classical engineering sciences" but also one of the main drivers of national and international technical progress in recent decades.

In engineering terms, electrical engineering deals with research, development and, in general, the application of electrical signals, electrical energy and electromagnetic fields in corresponding components and circuits.

Due to the widely ramified fields of application, a high degree of specialisation is required in the profession. As a consequence, the vocational training of electrical engineers is in the area of tension between the breadth of the training (for the widest possible range of later uses) and the depth of the training (for current, subject-specific competences). Within the framework of the consecutive Bachelor's/Master's degree programmes in electrical engineering at the TUHH, the breadth of the subject is taught primarily during the Bachelor's degree programme and focal points are deepened in the Master's degree programme. The Bachelor's programme conveys the fundamentals of electrical engineering, information technology, computer science as well as mathematics and physics required for solving electrical engineering and information technology tasks. In addition to the technical canon of fundamentals, training in non-technical areas such as business administration, patents, management, humanities, law and philosophy is aimed for, which meets the modern professional requirements of an engineer.

Career prospects

Successful completion of the Bachelor's degree programme in Electrical Engineering enables an early career entry into the typical fields of activity in electrical engineering, in addition to taking up a Master's degree programme that provides more in-depth scientific knowledge. These include communications engineering, measurement and control engineering, microsystems engineering and nanoelectronics, electrical power engineering, high-frequency engineering and optical systems.

Electrical engineers are among the most sought-after academics on the labour market. A current evaluation of data from the Federal Employment Agency proves the increasing demand (Federal Employment Agency: "Berichte: Blickpunkt Arbeitsmarkt - Ingenieurinnen und Ingenieure", Nuremberg, 2018). While the number of registered unemployed continues to fall steadily, the number of registered vacancies is increasing significantly at the same time. At the same time, only a fraction of the advertised jobs are reported to the Federal Employment Agency, so that the supply of jobs currently exceeds the demand. Thus, as in previous years, the demand for electrical engineers - especially in the old federal states including Hamburg - cannot be met ("shortage of skilled workers").

Learning target

The desired learning outcomes of the degree programme are based on the objectives listed above. The focus is on enabling graduates to responsibly and competently perform an engineering activity in the various fields of activity in electrical engineering. The learning objectives are divided into the following categories: knowledge, skills, social competence and independence.

Knowledge

- Students can name and describe the mathematical-scientific fundamentals and methods of engineering sciences. This includes, in particular, elements of higher analysis and linear algebra as well as physics.
- Students can explain the fundamentals and methods of electrical engineering and information technology and can give an overview of their subject. Of particular importance are direct and alternating current theory, circuit technology, the theory of electromagnetic fields and waves, the materials and components of electrical engineering as well as systems theory with their respective methods.
- The students can explain the basics, methods and areas of application of the sub-disciplines of electrical engineering in detail. Important sub-disciplines are electrical power engineering, communications engineering, circuit technology, measurement technology and control engineering.
- Students can reproduce the fundamentals and methods of economics and can give an overview of the relevant social, ethical, ecological and economic boundary conditions of their subject.

Skills

- The students can independently work on research questions using suitable methods, document their chosen solution path and present it to an expert audience.
- Students can solve problems from the fields of analysis, linear algebra, function theory and the theory of differential equations using the methods they have learned
- The students can assess the current and voltage behaviour in electrical networks, dimension simple circuits and analyse networks in the time and frequency domain. They can use semiconductor components such as transistors and diodes as well as operational amplifiers in their areas of application. They are able to plan electrical power supply systems in basic outlines and analyse the operating behaviour of electrical machines and calculate typical variables. They are able to clarify metrological issues and apply methods for describing and processing measurement data.
- The students can model, programme and adapt simple algorithms. They can design and test software and estimate its complexity. They are able to distinguish between the different levels of abstraction of today's computing systems.
- The students can apply different methods to solve Maxwell's equations for electromagnetic field problems. They can derive typical quantities from the fields and dimension them for application in practice.
- The students can describe and analyse linear, time-invariant systems with the methods of signal and system theory. They are able to design and evaluate simple communication and control systems.
- The students can generally map typical problems to their basic knowledge, find suitable solution methods and implement them. They can appropriately document the chosen solution in writing and present it to an audience in a clearly structured manner.

Social competence

- Students are able to present the procedure and results of their work in a comprehensible manner, both orally and in writing.
- The students are able to communicate about the contents and problems of electrical engineering with experts and laypersons. They can react appropriately to questions, additions and comments.
- The students are able to work in groups. They can define, distribute and integrate subtasks. They can make time arrangements and interact socially.

Competence to work independently

- The students are able to obtain necessary technical information and place it in the context of their knowledge
- The students can realistically assess their existing competences and work on deficits independently
- The students can learn complex topics and work on problems in a self-organised and self-motivated manner (lifelong learning).

Program structure

The curriculum of the Bachelor's degree programme in Electrical Engineering is structured as follows:

- Core qualification - compulsory: 24 modules, 144 credit points (LP), 1st - 6th semester.
- Core qualification - compulsory elective: 4 modules, 24 LP, 4th, 5th and 6th semester
- Bachelor thesis: 12 LP, 6th semester

The total workload for the Bachelor's programme is 180 LP, with a semester distribution of 30/28/32/30/30/30 LP.

In addition to the subject modules, the core qualification also includes the following interdisciplinary modules:

- Fundamentals of business administration: 6 LP, 1st semester
- Non-technical supplementary courses in the Bachelor: 6 LP, 1st - 6th semester

Core Qualification

Module M0577: Non-technical Courses for Bachelors

Module Responsible	Dagmar Richter
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	**The Non-technical Academic Programms (NTA)** imparts skills that, in view of the TUHH's training profile, professional engineering studies require but are not able to cover fully. Self-reliance, self-management, collaboration and professional and personnel management competences. The department implements these training objectives in its **teaching architecture**, in its **teaching and learning arrangements**, in **teaching areas** and by means of teaching offerings in which students can qualify by opting for **specific competences** and a **competence level** at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontechnical complementary courses. **The Learning Architecture** consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontechnical academic programms follow the specific profiling of TUHH degree courses. The learning architecture demands and trains independent educational planning as regards the individual development of competences. It also provides orientation knowledge in the form of "profiles" The subjects that can be studied in parallel throughout the student's entire study program - if need be, it can be studied in one to two semesters. In view of the adaptation problems that individuals commonly face in their first semesters after making the transition from school to university and in order to encourage individually planned semesters abroad, there is no obligation to study these subjects in one or two specific semesters during the course of studies. **Teaching and Learning Arrangements** provide for students, separated into B.Sc. and M.Sc., to learn with and from each other across semesters. The challenge of dealing with interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliberately encouraged in specific courses. **Fields of Teaching** are based on research findings from the academic disciplines cultural studies, social studies, arts, historical studies, migration studies, communication studies and sustainability research, and from engineering didactics. In addition, from the winter semester 2014/15 students on all Bachelor's courses will have the opportunity to learn about business management and start-ups in a goal-oriented way. The fields of teaching are augmented by soft skills offers and a foreign language offer. Here, the focus is on encouraging goal-oriented communication skills, e.g. the skills required by outgoing engineers in international and intercultural situations. **The Competence Level** of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These differences are reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scientific and theoretical level of abstraction in the B.Sc. This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leadership functions of Bachelor's and Master's graduates in their future working life. **Specialized Competence (Knowledge)** Students can • locate selected specialized areas with the relevant non-technical mother discipline, • outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area, • different specialist disciplines relate to their own discipline and differentiate it as well as make connections, • sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of representation in the specialized sciences are subject to individual and socio-cultural interpretation and historicity, • Can communicate in a foreign language in a manner appropriate to the subject.
Skills	**Professional Competence (Skills)** In selected sub-areas students can • apply basic methods of the said scientific disciplines, • auestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline, • to handle simple questions in aforementioned scientific disciplines in a sucsessful manner, • justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject.
Personal Competence	

Social Competence	**Personal Competences (Social Skills)** Students will be able • to learn to collaborate in different manner, • to present and analyze problems in the abovementioned fields in a partner or group situation in a manner appropriate to the addressees, • to express themselves competently, in a culturally appropriate and gender-sensitive manner in the language of the country (as far as this study-focus would be chosen), • to explain nontechnical items to auditorium with technical background knowledge.
Autonomy	**Personal Competences (Self-reliance)** Students are able in selected areas • to reflect on their own profession and professionalism in the context of real-life fields of application • to organize themselves and their own learning processes • to reflect and decide questions in front of a broad education background • to communicate a nontechnical item in a competent way in writen form or verbaly • to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen)
Workload in Hours	Depends on choice of courses
Credit points	6

Courses
Information regarding lectures and courses can be found in the corresponding module handbook published separately.

Module M0642: Physics for Engineers

Courses

Title	Typ	Hrs/wk	CP
Physics for Engineers (L0367)	Lecture	2	3
Physics for Engineers (Problem Solving Course) (L0368)	Recitation Section (small)	1	1
Physics-Lab for ET (L0948)	Practical Course	1	2

Module Responsible	Prof. Manfred Eich
Admission Requirements	None
Recommended Previous Knowledge	• Calculus and linear algebra on high school level • Physics on high school level
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can explain fundamental topics and laws of physics such as in the areas of mechanics, oscillations, waves, and optics. Students can relate physics topics to technical problems.
Skills	Students can describe physical problems mathematically and solve such problems within the framework of their acquired mathematical expertise. Students are able to write meaningful reports on experiments and to discuss the results in a conclusive way.
Personal Competence	
Social Competence	Students can jointly solve subject related problems in groups. They can present their results effectively within the framework of the problem solving and lab courses.
Autonomy	Students are capable to extract relevant information from the provided references and to relate this information to the content of the lecture. They can reflect their acquired level of expertise with the help of lecture accompanying measures such as exam typical exam questions. Students are able to connect their knowledge with that acquired from other lectures.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	Compulsory: Yes; Bonus: None; Form: Subject theoretical and practical work; Description: 4-seitige handschriftliche Versuchsvorbereitung, Ausarbeitung unter Anleitung und Testat
Examination	Written exam
Examination duration and scale	120 Minutes
Assignment for the Following Curricula	Digital Mechanical Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory

Course L0367: Physics for Engineers

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Manfred Eich
Language	DE
Cycle	WiSe
Content	• Introduction • Kinematics and dynamics • Work, Energy, momentum • Rotatory Motion, moments of inertia • Gravitation • Special Theory of Relativity • Oscillations • Waves • Geometrical optics • Wave optics • Matter waves • Fundamentals of quantum mechanics
Literature	• Giancoli, Physics for Scientists & Engineers Vol. 1, 2, Pearson • Halliday/Resnik/Walker, *Fundamentals of physics*, Wiley • K. Cummings, P. Laws, E. Redish, and P. Cooney (“CLRC”), *Understanding Physics,* Wiley • Gerthsen/Vogel, *Physik*, Springer Verlag • Hering/Martin/Stohrer, *Physik für Ingenieure*, VDI-Verlag

Course L0368: Physics for Engineers (Problem Solving Course)	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Manfred Eich
Language	DE
Cycle	WiSe
Content	see lecture Physics for Engineers
Literature	see lecture Physics for Engineers

Course L0948: Physics-Lab for ET	
Typ	Practical Course
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Wolfgang Hansen
Language	DE/EN
Cycle	SoSe
Content	In the physics lab a number of key experiments on physical phenomena in mechanics, oscillatory and wave motion, thermodynamics, electricity, and optics will be conducted by the students under assistance of a lecturing tutor. The experiments are part of the physics education program presented in the course "Physics for TUHH-ET Engineers". Beyond teaching of fundamental physical background the objectives are basic skills in preparation and performing physical measurements, usage of physical equipment, analysis of the results and preparation of a report on the experimental data.
Literature	Zu den Versuchen gibt es individuelle Versuchsanleitungen, die vor der Versuchsdurchführung ausgegeben werden. Zum Teil müssen die zur Versuchsdurchführung notwendigen physikalischen Hintergründe selbstständig erarbeitet werden, wozu die zur Vorlesung "Physik für TUHH-ET Ingenieure" angegebene Literatur gut geeignet ist.

Module M0743: Electrical Engineering I: Direct Current Networks and Electromagnetic Fields

Courses

Title	Typ	Hrs/wk	CP
Electrical Engineering I: Direct Current Networks and Electromagnetic Fields (L0675)	Lecture	3	5
Electrical Engineering I: Direct Current Networks and Electromagnetic Fields (L0676)	Recitation Section (small)	2	1

Module Responsible	Prof. Matthias Kuhl
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	100 Minutes
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory

Course L0675: Electrical Engineering I: Direct Current Networks and Electromagnetic Fields

Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Matthias Kuhl
Language	DE
Cycle	WiSe
Content	
Literature	1. M. Kasper, Skript zur Vorlesung Elektrotechnik 1, 2013 2. M. Albach: Grundlagen der Elektrotechnik 1, Pearson Education, 2004 3. F. Moeller, H. Frohne, K.H. Löcherer, H. Müller: Grundlagen der Elektrotechnik, Teubner, 2005 4. A. R. Hambley: Electrical Engineering, Principles and Applications, Pearson Education, 2008

Course L0676: Electrical Engineering I: Direct Current Networks and Electromagnetic Fields

Typ	Recitation Section (small)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Matthias Kuhl
Language	DE
Cycle	WiSe
Content	
Literature	1. Übungsaufgaben zur Elektrotechnik 1, TUHH, 2013 2. Ch. Kautz: Tutorien zur Elektrotechnik, Pearson Studium, 2010

Module M0829: Foundations of Management

Courses

Title	Typ	Hrs/wk	CP
Management Tutorial (L0882)	Recitation Section (small)	2	3
Introduction to Management (L0880)	Lecture	3	3

Module Responsible	Prof. Christoph Ihl
Admission Requirements	None
Recommended Previous Knowledge	Basic Knowledge of Mathematics and Business
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After taking this module, students know the important basics of many different areas in Business and Management, from Planning and Organisation to Marketing and Innovation, and also to Investment and Controlling. In particular they are able to • explain the differences between Economics and Management and the sub-disciplines in Management and to name important definitions from the field of Management • explain the most important aspects of and goals in Management and name the most important aspects of entreprneurial projects • describe and explain basic business functions as production, procurement and sourcing, supply chain management, organization and human ressource management, information management, innovation management and marketing • explain the relevance of planning and decision making in Business, esp. in situations under multiple objectives and uncertainty, and explain some basic methods from mathematical Finance • state basics from accounting and costing and selected controlling methods.
Skills	Students are able to analyse business units with respect to different criteria (organization, objectives, strategies etc.) and to carry out an Entrepreneurship project in a team. In particular, they are able to • analyse Management goals and structure them appropriately • analyse organisational and staff structures of companies • apply methods for decision making under multiple objectives, under uncertainty and under risk • analyse production and procurement systems and Business information systems • analyse and apply basic methods of marketing • select and apply basic methods from mathematical finance to predefined problems • apply basic methods from accounting, costing and controlling to predefined problems
Personal Competence	
Social Competence	Students are able to • work successfully in a team of students • to apply their knowledge from the lecture to an entrepreneurship project and write a coherent report on the project • to communicate appropriately and • to cooperate respectfully with their fellow students.
Autonomy	Students are able to • work in a team and to organize the team themselves • to write a report on their project.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	several written exams during the semester
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Civil- and Environmental Engineering: Specialisation Civil Engineering: Elective Compulsory Civil- and Environmental Engineering: Specialisation Water and Environment: Elective Compulsory Civil- and Environmental Engineering: Specialisation Traffic and Mobility: Elective Compulsory Bioprocess Engineering: Core Qualification: Compulsory Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Compulsory Data Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Logistics and Mobility: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Orientation Studies: Core Qualification: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Technomathematics: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory

Course L0882: Management Tutorial	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christoph Ihl, Katharina Roedelius
Language	DE
Cycle	WiSe/SoSe
Content	In the management tutorial, the contents of the lecture will be deepened by practical examples and the application of the discussed tools. If there is adequate demand, a problem-oriented tutorial will be offered in parallel, which students can choose alternatively. Here, students work in groups on se selected projects that focus on the elaboration of an innovative business idea from the point of view of an established company or a startup. Again, the busin knowledge from the lecture should come to practical use. The group projects are guided by a mentor.
Literature	Relevante Literatur aus der korrespondierenden Vorlesung.

Course L0880: Introduction to Management	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Christoph Ihl, Prof. Christian Lüthje, Prof. Christian Ringle, Prof. Cornelius Herstatt, Prof. Kathrin Fischer, Prof. Matthias Meyer, Prof. Thomas Wrona, Prof. Thorsten Blecker, Prof. Wolfgang Kersten
Language	DE
Cycle	WiSe/SoSe
Content	• Introduction to Business and Management, Business versus Economics, relevant areas in Business and Management • Important definitions from Management, • Developing Objectives for Business, and their relation to important Business functions • Business Functions: Functions of the Value Chain, e.g. Production and Procurement, Supply Chain Management, Innovation Management, Marketing and Sales Cross-sectional Functions, e.g. Organisation, Human Ressource Management, Supply Chain Management, Information Management • Definitions as information, information systems, aspects of data security and strategic information systems • Definition and Relevance of innovations, e.g. innovation opporunities, risks etc. • Relevance of marketing, B2B vs. B2C-Marketing • different techniques from the field of marketing (e.g. scenario technique), pricing strategies • important organizational structures • basics of human ressource management • Introduction to Business Planning and the steps of a planning process • Decision Analysis: Elements of decision problems and methods for solving decision problems • Selected Planning Tasks, e.g. Investment and Financial Decisions • Introduction to Accounting: Accounting, Balance-Sheets, Costing • Relevance of Controlling and selected Controlling methods • Important aspects of Entrepreneurship projects
Literature	Bamberg, G., Coenenberg, A.: Betriebswirtschaftliche Entscheidungslehre, 14. Aufl., München 2008 Eisenführ, F., Weber, M.: Rationales Entscheiden, 4. Aufl., Berlin et al. 2003 Heinhold, M.: Buchführung in Fallbeispielen, 10. Aufl., Stuttgart 2006. Kruschwitz, L.: Finanzmathematik. 3. Auflage, München 2001. Pellens, B., Fülbier, R. U., Gassen, J., Sellhorn, T.: Internationale Rechnungslegung, 7. Aufl., Stuttgart 2008. Schweitzer, M.: Planung und Steuerung, in: Bea/Friedl/Schweitzer: Allgemeine Betriebswirtschaftslehre, Bd. 2: Führung, 9. Aufl., Stuttgart 2005. Weber, J., Schäffer, U. : Einführung in das Controlling, 12. Auflage, Stuttgart 2008. Weber, J./Weißenberger, B.: Einführung in das Rechnungswesen, 7. Auflage, Stuttgart 2006.

Module M0850: Mathematics I

Courses

Title	Typ	Hrs/wk	CP
Mathematics I (L2970)	Lecture	4	4
Mathematics I (L2971)	Recitation Section (large)	2	2
Mathematics I (L2972)	Recitation Section (small)	2	2

Module Responsible	Prof. Anusch Taraz
Admission Requirements	None
Recommended Previous Knowledge	School mathematics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name the basic concepts in analysis and linear algebra. They are able to explain them using appropriate examples. • Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples. • They know proof strategies and can reproduce them.
Skills	• Students can model problems in analysis and linear algebra with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods. • Students are able to discover and verify further logical connections between the concepts studied in the course. • For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.
Personal Competence	
Social Competence	• Students are able to work together in teams. They are capable to use mathematics as a common language. • In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.
Autonomy	• Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them. • Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.
Workload in Hours	Independent Study Time 128, Study Time in Lecture 112
Credit points	8
Course achievement	Compulsory: Yes; Bonus: 10 %; Form: Excercises; Description:
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Civil- and Environmental Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Logistics and Mobility: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory

Course L2970: Mathematics I	
Typ	Lecture
Hrs/wk	4
CP	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Anusch Taraz
Language	DE
Cycle	WiSe
Content	Mathematical Foundations: sets, statements, induction, mappings, trigonometry Analysis: Foundations of differential calculus in one variable • natural and real numbers • convergence of sequences and series • continuous and differentiable functions • mean value theorems • Taylor series • calculus • error analysis • fixpoint iteration Linear Algebra: Foundations of linear algebra in R^n • vectors: rules, linear combinations, inner and cross product, lines and planes • systems of linear equations: Gauß elimination, linear mappings, matrix multiplication, inverse matrices, determinants • orthogonal projection in R^n, Gram-Schmidt-Orthonormalization
Literature	• T. Arens u.a. : Mathematik, Springer Spektrum, Heidelberg 2015 • W. Mackens, H. Voß: Mathematik I für Studierende der Ingenieurwissenschaften, HECO-Verlag, Alsdorf 1994 • W. Mackens, H. Voß: Aufgaben und Lösungen zur Mathematik I für Studierende der Ingenieurwissenschaften, HECO-Verlag, Alsdorf 1994 • G. Strang: Lineare Algebra, Springer-Verlag, 2003 • G. und S. Teschl: Mathematik für Informatiker, Band 1, Springer-Verlag, 2013

Course L2971: Mathematics I	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Anusch Taraz, Dr. Dennis Clemens, Dr. Simon Campese
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L2972: Mathematics I	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Anusch Taraz
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1692: Computer Science for Engineers - Introduction and Overview

Courses

Title	Typ	Hrs/wk	CP
Computer Science for Engineers - Introduction and Overview (L2685)	Lecture	3	3
Computer Science for Engineers - Introduction and Overview (L2686)	Recitation Section (small)	2	3

Module Responsible	Prof. Görschwin Fey
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	Compulsory: No; Bonus: 10 %; Form: Attestation; Description: Testate finden semesterbegleitend statt.
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Logistics and Mobility: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory

Course L2685: Computer Science for Engineers - Introduction and Overview

Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Görschwin Fey
Language	DE/EN
Cycle	WiSe
Content	

Literature	• Informatik
	  ◦ Helmut Herold, Bruno Lurz, Jürgen Wohlrab, Matthias Hopf: Grundlagen der Informatik, 3. Auflage, 816 Seiten, Pearson Studium, 2017.
	• C++
	  ◦ Bjarne Stroustrup, Einführung in die Programmierung mit C++, 479 Seiten, Pearson Studium, 2010.
	  --> in der englischen Version bereits eine neuere Auflage!
	  ◦ Jürgen Wolf : Grundkurs C++: C++-Programmierung verständlich erklärt, Rheinwerk Computing, 3. Auflage, 2016.

Course L2686: Computer Science for Engineers - Introduction and Overview

Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Görschwin Fey
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0547: Electrical Engineering II: Alternating Current Networks and Basic Devices

Courses

Title	Typ	Hrs/wk	CP
Electrical Engineering II: Alternating Current Networks and Basic Devices (L0178)	Lecture	3	5
Electrical Engineering II: Alternating Current Networks and Basic Devices (L0179)	Recitation Section (small)	2	1

Module Responsible	Prof. Christian Becker
Admission Requirements	None
Recommended Previous Knowledge	Electrical Engineering I Mathematics I Direct current networks, complex numbers
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to reproduce and explain fundamental theories, principles, and methods related to the theory of alternating currents. They can describe networks of linear elements using a complex notation for voltages and currents. They can reproduce an overview of applications for the theory of alternating currents in the area of electrical engineering. Students are capable of explaining the behavior of fundamental passive and active devices as well as their impact on simple circuits.
Skills	Students are capable of calculating parameters within simple electrical networks at alternating currents by means of a complex notation for voltages and currents. They can appraise the fundamental effects that may occur within electrical networks at alternating currents. Students are able to analyze simple circuits such as oscillating circuits, filter, and matching networks quantitatively and dimension elements by means of a design. They can motivate and justify the fundamental elements of an electrical power supply (transformer, transmission line, compensation of reactive power, multiphase system) and are qualified to dimension their main features.
Personal Competence	
Social Competence	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively.
Autonomy	Students are capable to gather necessary information from the references provided and relate that information to the context of the lecture. They are able to continually reflect their knowledge by means of activities that accompany the lecture, such as online-tests and exercises that are related to the exam. Based on respective feedback, students are expected to adjust their individual learning process. They are able to draw connections between their knowledge obtained in this lecture and the content of other lectures (e.g. Electrical Engineering I, Linear Algebra, and Analysis).
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** **Bonus** **Form** **Description** No 10 % Midterm
Examination	Written exam
Examination duration and scale	90 - 150 minutes
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory

Course L0178: Electrical Engineering II: Alternating Current Networks and Basic Devices	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Christian Becker
Language	DE
Cycle	SoSe
Content	- General time-dependency of electrical networks - Representation and properties of harmonic signals - RLC-elements at alternating currents/voltages - Complex notation for the representation of RLC-elements - Power in electrical networks at alternating currents, compensation of reactive power - Frequency response locus (Nyquist plot) and Bode-diagrams - Measurement instrumentation for assessing alternating currents - Oscillating circuits, filters, electrical transmission lines - Transformers, three-phase current, energy converters - Simple non-linear and active electrical devices
Literature	- M. Albach, "Elektrotechnik", Pearson Studium (2011) - T. Harriehausen, D. Schwarzenau, "Moeller Grundlagen der Elektrotechnik", Springer (2013) - R. Kories, H. Schmidt-Walter, "Taschenbuch der Elektrotechnik", Harri Deutsch (2010) - C. Kautz, "Tutorien zur Elektrotechnik", Pearson (2009) - A. Hambley, "Electrical Engineering: Principles and Applications", Pearson (2013) - R. Dorf, "The Electrical Engineering Handbook", CRC (2006)

Course L0179: Electrical Engineering II: Alternating Current Networks and Basic Devices	
Typ	Recitation Section (small)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Christian Becker
Language	DE
Cycle	SoSe
Content	- General time-dependency of electrical networks - Representation and properties of harmonic signals - RLC-elements at alternating currents/voltages - Complex notation for the representation of RLC-elements - Power in electrical networks at alternating currents, compensation of reactive power - Frequency response locus (Nyquist plot) and Bode-diagrams - Measurement instrumentation for assessing alternating currents - Oscillating circuits, filters, electrical transmission lines - Transformers, three-phase current, energy converters - Simple non-linear and active electrical devices
Literature	- M. Albach, "Elektrotechnik", Pearson Studium (2011) - T. Harriehausen, D. Schwarzenau, "Moeller Grundlagen der Elektrotechnik", Springer (2013) - R. Kories, H. Schmidt-Walter, "Taschenbuch der Elektrotechnik", Harri Deutsch (2010) - C. Kautz, "Tutorien zur Elektrotechnik", Pearson (2009) - A. Hambley, "Electrical Engineering: Principles and Applications", Pearson (2013) - R. Dorf, "The Electrical Engineering Handbook", CRC (2006)

Module M0748: Materials in Electrical Engineering

Courses

Title	Typ	Hrs/wk	CP
Electrotechnical Experiments (L0714)	Lecture	1	1
Materials in Electrical Engineering (L0685)	Lecture	2	3
Materials in Electrical Engineering (Problem Solving Course) (L0687)	Recitation Section (small)	2	2

Module Responsible	Prof. Manfred Eich
Admission Requirements	None
Recommended Previous Knowledge	Highschool level physics and mathematics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can explain the composition and the structural properties of materials used in electrical engineering. Students can explicate the relevance of mechanical, electrical, thermal, dielectric, magnetic and chemical properties of materials in view of their applications in electrical engineering.
Skills	Students can identify appropriate descriptive models and apply them mathematically. They can derive approximative solutions and judge factors influential on the performance of materials in electrical engineering applications.
Personal Competence	
Social Competence	Students can jointly solve subject related problems in groups. They can present their results effectively within the framework of the problem solving course.
Autonomy	Students are capable to extract relevant information from the provided references and to relate this information to the content of the lecture. They can reflect their acquired level of expertise with the help of lecture accompanying measures such as exam typical exam questions. Students are able to connect their knowledge with that acquired from other lectures.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	60 minutes
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory Electrical Engineering: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory

Course L0714: Electrotechnical Experiments	
Typ	Lecture
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Helge Fielitz
Language	DE
Cycle	SoSe
Content	Agenda: - Natural sources of electricity - Oscilloscope - Characterizing signals - 2 terminal circuit elements - 2-ports - Power - Matching - Inductive coupling - Resonance - Radio frequencies - Transistor circuits - Electrical measurement - Materials for the EE - Electrical fun
Literature	Tietze, Schenk: "Halbleiterschaltungstechnik", Springer

Course L0685: Materials in Electrical Engineering	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Manfred Eich
Language	DE
Cycle	SoSe
Content	The Hamiltonian approach to classical mechanics. Analysis of a simple oscillator. Analysis of vibrations in a one-dimensional lattice. Phononic bandgap Introduction to quantum mechanics Wave function, Schrödinger's equation, observables and measurements. Quantum mechanical harmonic oscillator and spectral decomposition. Symmetries, conserved quantities, and the labeling of states. Angular momentum The hydrogen atom Waves in periodic potentials Reciprocal lattice and reciprocal lattice vectors Band gap Band diagrams The free electron gas and the density of states Fermi-Dirac distribution Density of charge carriers in semiconductors Conductivity in semiconductors. Engineering conductivity through doping. The P-N junction (diode) Light emitting diodes Electromagnetic waves interacting with materials Reflection and refraction Photonic band gaps Origins of magnetization Hysteresis in ferromagnetic materials Magnetic domains
Literature	1.Anikeeva, Beach, Holten-Andersen, Fink, Electronic, Optical and Magnetic Properties of Materials, Massachusetts Institute of Technology (MIT), 2013 2.Hagelstein et al., Introductory Applied Quantum and Statistical Mechanics, Wiley 2004 3.Griffiths, Introduction to Quantum Mechanics, Prentice Hall, 1994 4.Shankar, Principles of Quantum Mechanics, 2nd ed., Plenum Press, 1994 5.Fick, Einführung in die Grundlagen der Quantentheorie, Akad. Verlagsges., 1979 6.Kittel, Introduction to Solid State Physics, 8th ed., Wiley, 2004 7.Ashcroft, Mermin, Solid State Physics, Harcourt, 1976 8.Pierret, Semiconductor Fundamentals Vol. 1, Addison Wesley, 1988 9.Sze, Physics of Semiconductor Devices, Wiley, 1981 10.Saleh, Teich, Fundamentals of Photonics, 2nd ed., 2007 11.Joannopoulos, Johnson, Winn Meade, Photonic Crystals, 2nd ed., Princeton Universty Press, 2008 12.Handley, Modern Magnetic Materials, Wiley, 2000 13.Wikipedia, Wikimedia

Course L0687: Materials in Electrical Engineering (Problem Solving Course)	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Manfred Eich
Language	DE
Cycle	SoSe
Content	• Atom structure and periodic system • Atom binding and crystal structure • Structure and properties of alloys: diffusion, phase diagrams, phase separation and grain boundaries • Material properties: Mechanical, thermal, electrical, dielectric properties • Metals • Semiconductors • Ceramics and glasses • Polymers • Magnetic materials • Electrochemistry Oxidation numbers, electrolysis, batteries, fuel cells
Literature	H. Schaumburg: Einführung in die Werkstoffe der Elektrotechnik, Teubner (1993)

Module M0851: Mathematics II

Courses

Title	Typ	Hrs/wk	CP
Mathematics II (L2976)	Lecture	4	4
Mathematics II (L2977)	Recitation Section (large)	2	2
Mathematics II (L2978)	Recitation Section (small)	2	2

Module Responsible	Prof. Anusch Taraz
Admission Requirements	None
Recommended Previous Knowledge	Mathematics I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name further concepts in analysis and linear algebra. They are able to explain them using appropriate examples. • Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples. • They know proof strategies and can reproduce them.
Skills	• Students can model problems in analysis and linear algebra with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods. • Students are able to discover and verify further logical connections between the concepts studied in the course. • For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.
Personal Competence	
Social Competence	• Students are able to work together in teams. They are capable to use mathematics as a common language. • In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.
Autonomy	• Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them. • Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.
Workload in Hours	Independent Study Time 128, Study Time in Lecture 112
Credit points	8
Course achievement	Compulsory: Yes; Bonus: 10 %; Form: Excercises; Description:
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Civil- and Environmental Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Logistics and Mobility: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory

Course L2976: Mathematics II	
Typ	Lecture
Hrs/wk	4
CP	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Anusch Taraz
Language	DE
Cycle	SoSe
Content	
Literature	

Course L2977: Mathematics II	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Anusch Taraz
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L2978: Mathematics II	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Anusch Taraz
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1693: Computer Science for Engineers - Programming Concepts, Data Handling & Communication

Courses

Title	Typ	Hrs/wk	CP
Computer Science for Engineers - Programming Concepts, Data Handling & Communication (L2689)	Lecture	3	3
Computer Science for Engineers - Programming Concepts, Data Handling & Communication (L2690)	Recitation Section (small)	2	3

Module Responsible	Prof. Sibylle Fröschle
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	Compulsory: No; Bonus: 10 %; Form: Attestation; Description: Testate finden semesterbegleitend statt.
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Systems: Elective Compulsory Logistics and Mobility: Specialisation Information Technology: Compulsory Mechatronics: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Compulsory

Course L2689: Computer Science for Engineers - Programming Concepts, Data Handling & Communication

Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Sibylle Fröschle
Language	DE
Cycle	SoSe
Content	
Literature	John V. Guttag: Introduction to Computation and Programming Using Python. With Application to Understanding Data. 2nd Edition. The MIT Press, 2016.

Course L2690: Computer Science for Engineers - Programming Concepts, Data Handling & Communication	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Sibylle Fröschle
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0783: Measurements: Methods and Data Processing

Courses

Title	Typ	Hrs/wk	CP
EE Experimental Lab (L0781)	Practical Course	2	2
Measurements: Methods and Data Processing (L0779)	Lecture	2	3
Measurements: Methods and Data Processing (L0780)	Recitation Section (small)	1	1

Module Responsible	Prof. Alexander Schlaefer
Admission Requirements	None
Recommended Previous Knowledge	principles of mathematics principles of electrical engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to explain the purpose of metrology and the acquisition and processing of measurements. They can detail aspects of probability theory and errors, and explain the processing of stochastic signals. Students know methods to digitalize and describe measured signals.
Skills	The students are able to evaluate problems of metrology and to apply methods for describing and processing of measurements.
Personal Competence	
Social Competence	The students solve problems in small groups.
Autonomy	The students can reflect their knowledge and discuss and evaluate their results.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** **Bonus** **Form** **Description** Yes 10 % Excercises
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory Electrical Engineering: Core Qualification: Compulsory Engineering Science: Specialisation Electrical Engineering: Elective Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Integrated Building Technology: Core Qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0781: EE Experimental Lab

Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer, Dozenten des SD E, Prof. Alexander Kölpin, Prof. Bernd-Christian Renner, Prof. Christian Becker, Prof. Heiko Falk, Prof. Herbert Werner, Prof. Thorsten Kern
Language	DE
Cycle	WiSe
Content	lab experiments: digital circuits, semiconductors, micro controllers, analog circuits, AC power, electrical machines
Literature	Wird in der Lehrveranstaltung festgelegt

Course L0779: Measurements: Methods and Data Processing

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	DE
Cycle	WiSe
Content	introduction, systems and errors in metrology, probability theory, measuring stochastic signals, describing measurements, acquisition of analog signals, applied metrology
Literature	Puente León, Kiencke: Messtechnik, Springer 2012 Lerch: Elektrische Messtechnik, Springer 2012 Weitere Literatur wird in der Veranstaltung bekanntgegeben.

Course L0780: Measurements: Methods and Data Processing	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alexander Schlaefer
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0708: Electrical Engineering III: Circuit Theory and Transients

Courses

Title	Typ	Hrs/wk	CP
Circuit Theory (L0566)	Lecture	3	4
Circuit Theory (L0567)	Recitation Section (small)	2	2

Module Responsible	Prof. Alexander Kölpin
Admission Requirements	None
Recommended Previous Knowledge	Electrical Engineering I and II, Mathematics I and II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to explain the basic methods for calculating electrical circuits. They know the Fourier series analysis of linear networks driven by periodic signals. They know the methods for transient analysis of linear networks in time and in frequency domain, and they are able to explain the frequency behaviour and the synthesis of passive two-terminal-circuits.
Skills	The students are able to calculate currents and voltages in linear networks by means of basic methods, also when driven by periodic signals. They are able to calculate transients in electrical circuits in time and frequency domain and are able to explain the respective transient behaviour. They are able to analyse and to synthesize the frequency behaviour of passive two-terminal-circuits.
Personal Competence	
Social Competence	Students work on exercise tasks in small guided groups. They are encouraged to present and discuss their results within the group.
Autonomy	The students are able to find out the required methods for solving the given practice problems. Possibilities are given to test their knowledge during the lectures continuously by means of short-time tests. This allows them to control independently their educational objectives. They can link their gained knowledge to other courses like Electrical Engineering I and Mathematics I.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	150 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory Electrical Engineering: Core Qualification: Compulsory Engineering Science: Specialisation Electrical Engineering: Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Mechatronics: Specialisation Electrical Systems: Compulsory Mechatronics: Specialisation Dynamic Systems and AI: Compulsory Mechatronics: Core Qualification: Compulsory Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0566: Circuit Theory	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Alexander Kölpin, Dr. Fabian Lurz
Language	DE
Cycle	WiSe
Content	- Circuit theorems - N-port circuits - Periodic excitation of linear circuits - Transient analysis in time domain - Transient analysis in frequency domain; Laplace Transform - Frequency behaviour of passive one-ports
Literature	- M. Albach, "Grundlagen der Elektrotechnik 1", Pearson Studium (2011) - M. Albach, "Grundlagen der Elektrotechnik 2", Pearson Studium (2011) - L. P. Schmidt, G. Schaller, S. Martius, "Grundlagen der Elektrotechnik 3", Pearson Studium (2011) - T. Harriehausen, D. Schwarzenau, "Moeller Grundlagen der Elektrotechnik", Springer (2013) - A. Hambley, "Electrical Engineering: Principles and Applications", Pearson (2008) - R. C. Dorf, J. A. Svoboda, "Introduction to electrical circuits", Wiley (2006) - L. Moura, I. Darwazeh, "Introduction to Linear Circuit Analysis and Modeling", Amsterdam Newnes (2005)

Course L0567: Circuit Theory	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Alexander Kölpin, Dr. Fabian Lurz
Language	DE
Cycle	WiSe
Content	see interlocking course
Literature	siehe korrespondierende Lehrveranstaltung

Module M0730: Computer Engineering

Courses

Title	Typ	Hrs/wk	CP
Computer Engineering (L0321)	Lecture	3	4
Computer Engineering (L0324)	Recitation Section (small)	1	2

Module Responsible	Prof. Heiko Falk
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in electrical engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	This module deals with the foundations of the functionality of computing systems. It covers the layers from the assembly-level programming down to gates. The module includes the following topics: • Introduction • Combinational logic: Gates, Boolean algebra, Boolean functions, hardware synthesis, combinational networks • Sequential logic: Flip-flops, automata, systematic hardware design • Technological foundations • Computer arithmetic: Integer addition, subtraction, multiplication and division • Basics of computer architecture: Programming models, MIPS single-cycle architecture, pipelining • Memories: Memory hierarchies, SRAM, DRAM, caches • Input/output: I/O from the perspective of the CPU, principles of passing data, point-to-point connections, busses
Skills	The students perceive computer systems from the architect's perspective, i.e., they identify the internal structure and the physical composition of computer systems. The students can analyze, how highly specific and individual computers can be built based on a collection of few and simple components. They are able to distinguish between and to explain the different abstraction layers of today's computing systems - from gates and circuits up to complete processors. After successful completion of the module, the students are able to judge the interdependencies between a physical computer system and the software executed on it. In particular, they shall understand the consequences that the execution of software has on the hardware-centric abstraction layers from the assembly language down to gates. This way, they will be enabled to evaluate the impact that these low abstraction levels have on an entire system's performance and to propose feasible options.
Personal Competence	
Social Competence	Students are able to solve similar problems alone or in a group and to present the results accordingly.
Autonomy	Students are able to acquire new knowledge from specific literature and to associate this knowledge with other classes.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** Yes / 10 % / Excercises
Examination	Written exam
Examination duration and scale	90 minutes, contents of course and labs
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Elective Compulsory Data Science: Specialisation I. Mathematics/Computer Science: Elective Compulsory Electrical Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory

Course L0321: Computer Engineering	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Heiko Falk
Language	DE/EN
Cycle	WiSe
Content	• Introduction • Combinational Logic • Sequential Logic • Technological Foundations • Representations of Numbers, Computer Arithmetics • Foundations of Computer Architecture • Memories • Input/Output
Literature	• A. Clements. The Principles of Computer Hardware. 3. Auflage, Oxford University Press, 2000. • A. Tanenbaum, J. Goodman. Computerarchitektur. Pearson, 2001. • D. Patterson, J. Hennessy. Rechnerorganisation und -entwurf. Elsevier, 2005.

Course L0324: Computer Engineering	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Heiko Falk
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0853: Mathematics III

Courses

Title	Typ	Hrs/wk	CP
Analysis III (L1028)	Lecture	2	2
Analysis III (L1029)	Recitation Section (small)	1	1
Analysis III (L1030)	Recitation Section (large)	1	1
Differential Equations 1 (Ordinary Differential Equations) (L1031)	Lecture	2	2
Differential Equations 1 (Ordinary Differential Equations) (L1032)	Recitation Section (small)	1	1
Differential Equations 1 (Ordinary Differential Equations) (L1033)	Recitation Section (large)	1	1

Module Responsible	Prof. Marko Lindner
Admission Requirements	None
Recommended Previous Knowledge	Mathematics I + II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name the basic concepts in the area of analysis and differential equations. They are able to explain them using appropriate examples. • Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples. • They know proof strategies and can reproduce them.
Skills	• Students can model problems in the area of analysis and differential equations with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods. • Students are able to discover and verify further logical connections between the concepts studied in the course. • For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.
Personal Competence	
Social Competence	• Students are able to work together in teams. They are capable to use mathematics as a common language. • In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.
Autonomy	• Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them. • Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.
Workload in Hours	Independent Study Time 128, Study Time in Lecture 112
Credit points	8
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min (Analysis III) + 60 min (Differential Equations 1)
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Civil- and Environmental Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory Logistics and Mobility: Specialisation Information Technology: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Naval Architecture: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Compulsory

Course L1028: Analysis III	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	WiSe
Content	Main features of differential and integrational calculus of several variables • Differential calculus for several variables • Mean value theorems and Taylor's theorem • Maximum and minimum values • Implicit functions • Minimization under equality constraints • Newton's method for multiple variables • Fourier series • Double integrals over general regions • Line and surface integrals • Theorems of Gauß and Stokes
Literature	• http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html

Course L1029: Analysis III	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1030: Analysis III	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1031: Differential Equations 1 (Ordinary Differential Equations)	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	WiSe
Content	Main features of the theory and numerical treatment of ordinary differential equations • Introduction and elementary methods • Exsitence and uniqueness of initial value problems • Linear differential equations • Stability and qualitative behaviour of the solution • Boundary value problems and basic concepts of calculus of variations • Eigenvalue problems • Numerical methods for the integration of initial and boundary value problems • Classification of partial differential equations
Literature	• http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html

Course L1032: Differential Equations 1 (Ordinary Differential Equations)	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1033: Differential Equations 1 (Ordinary Differential Equations)	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0567: Theoretical Electrical Engineering I: Time-Independent Fields

Courses

Title	Typ	Hrs/wk	CP
Theoretical Electrical Engineering I: Time-Independent Fields (L0180)	Lecture	3	5
Theoretical Electrical Engineering I: Time-Independent Fields (L0181)	Recitation Section (small)	2	1

Module Responsible	Prof. Christian Schuster
Admission Requirements	None
Recommended Previous Knowledge	Basic principles of electrical engineering and advanced mathematics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can explain the fundamental formulas, relations, and methods of the theory of time-independent electromagnetic fields. They can explicate the principal behavior of electrostatic, magnetostatic, and current density fields with regard to respective sources. They can describe the properties of complex electromagnetic fields by means of superposition of solutions for simple fields. The students are aware of applications for the theory of time-independent electromagnetic fields and are able to explicate these.
Skills	Students can apply Maxwell's Equations in integral notation in order to solve highly symmetrical, time-independent, electromagnetic field problems. Furthermore, they are capable of applying a variety of methods that require solving Maxwell's Equations for more general problems. The students can assess the principal effects of given time-independent sources of fields and analyze these quantitatively. They can deduce meaningful quantities for the characterization of electrostatic, magnetostatic, and electrical flow fields (capacitances, inductances, resistances, etc.) from given fields and dimension them for practical applications.
Personal Competence	
Social Competence	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively (e.g. during exercise sessions).
Autonomy	Students are capable to gather necessary information from provided references and relate this information to the lecture. They are able to continually reflect their knowledge by means of activities that accompany the lecture, such as short oral quizzes during the lectures and exercises that are related to the exam. Based on respective feedback, students are expected to adjust their individual learning process. They are able to draw connections between their knowledge obtained in this lecture and the content of other lectures (e.g. Electrical Engineering I, Linear Algebra, and Analysis).
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90-150 minutes
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory Electrical Engineering: Core Qualification: Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Mechatronics: Specialisation Electrical Systems: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0180: Theoretical Electrical Engineering I: Time-Independent Fields	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	DE
Cycle	SoSe
Content	- Maxwell’s Equations in integral and differential notation - Boundary conditions - Laws of conservation for energy and charge - Classification of electromagnetic field properties - Integral characteristics of time-independent fields (R, L, C) - Generic approaches to solving Poisson’s Equation - Electrostatic fields and specific methods of solving - Magnetostatic fields and specific methods of solving - Fields of electrical current density and specific methods of solving - Action of force within time-independent fields - Numerical methods for solving time-independent problems The practical application of numerical methods will be trained within specifically prepared lectures in an interactive manner using small MATLAB programs.
Literature	- G. Lehner, "Elektromagnetische Feldtheorie: Für Ingenieure und Physiker", Springer (2010) - H. Henke, "Elektromagnetische Felder: Theorie und Anwendung", Springer (2011) - W. Nolting, "Grundkurs Theoretische Physik 3: Elektrodynamik", Springer (2011) - D. Griffiths, "Introduction to Electrodynamics", Pearson (2012) - J. Edminister, " Schaum's Outline of Electromagnetics", Mcgraw-Hill (2013) - Richard Feynman, "Feynman Lectures on Physics: Volume 2", Basic Books (2011)

Course L0181: Theoretical Electrical Engineering I: Time-Independent Fields	
Typ	Recitation Section (small)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Christian Schuster
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0610: Electrical Machines and Actuators

Courses

Title	Typ	Hrs/wk	CP
Electrical Machines and Actuators (L0293)	Lecture	3	4
Electrical Machines and Actuators (L0294)	Recitation Section (large)	2	2

Module Responsible	Prof. Thorsten Kern
Admission Requirements	None
Recommended Previous Knowledge	Basics of mathematics, in particular complexe numbers, integrals, differentials Basics of electrical engineering and mechanical engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can to draw and explain the basic principles of electric and magnetic fields. They can describe the function of the standard types of electric machines and present the corresponding equations and characteristic curves. For typically used drives they can explain the major parameters of the energy efficiency of the whole system from the power grid to the driven engine.
Skills	Students are able to calculate two-dimensional electric and magnetic fields in particular ferromagnetic circuits with air gap. For this they apply the usual methods of the design auf electric machines. They can calulate the operational performance of electric machines from their given characteristic data and selected quantities and characteristic curves. They apply the usual equivalent circuits and graphical methods.
Personal Competence	
Social Competence	none
Autonomy	Students are able independently to calculate electric and magnatic fields for applications. They are able to analyse independently the operational performance of electric machines from the charactersitic data and theycan calculate thereof selected quantities and characteristic curves.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Design of four machines and actuators, review of design files
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Engineering Science: Specialisation Electrical Engineering: Elective Compulsory Engineering Science: Specialisation Electrical Engineering: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory Mechanical Engineering: Core Qualification: Elective Compulsory Mechatronics: Specialisation Naval Engineering: Compulsory Mechatronics: Core Qualification: Compulsory Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory Mechatronics: Specialisation Electrical Systems: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory

Course L0293: Electrical Machines and Actuators	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Thorsten Kern, Dennis Kähler
Language	DE
Cycle	SoSe
Content	Electric field: Coulomb´s law, flux (field) line, work, potential, capacitor, energy, force, capacitive actuators Magnetic field: force, flux line, Ampere´s law, field at bounderies, flux, magnetic circuit, hysteresis, induction, self-induction, mutual inductance, transformer, electromagnetic actuators Synchronous machines, construction and layout, equivalent single line diagrams, no-load and short-cuircuit characteristics, vector diagrams, motor and generator operation, stepper motors DC-Machines: Construction and layout, torque generation mechanismen, torque vs speed characteristics, commutation, Asynchronous Machines. Magnetic field, construction and layout, equivalent single line diagram, complex stator current diagram (Heylands´diagram), torque vs. speed characteristics, rotor layout (squirrel-cage vs. sliprings), Drives with variable speed, inverter fed operation, special drives
Literature	Hermann Linse, Roland Fischer: "Elektrotechnik für Maschinenbauer", Vieweg-Verlag; Signatur der Bibliothek der TUHH: ETB 313 Ralf Kories, Heinz Schmitt-Walter: "Taschenbuch der Elektrotechnik"; Verlag Harri Deutsch; Signatur der Bibliothek der TUHH: ETB 122 "Grundlagen der Elektrotechnik" - anderer Autoren Fachbücher "Elektrische Maschinen"

Course L0294: Electrical Machines and Actuators	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Thorsten Kern, Dennis Kähler
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0672: Signals and Systems

Courses

Title	Typ	Hrs/wk	CP
Signals and Systems (L0432)	Lecture	3	4
Signals and Systems (L0433)	Recitation Section (small)	2	2

Module Responsible	Prof. Gerhard Bauch
Admission Requirements	None
Recommended Previous Knowledge	Mathematics 1-3 The modul is an introduction to the theory of signals and systems. Good knowledge in maths as covered by the moduls Mathematik 1-3 is expected. Further experience with spectral transformations (Fourier series, Fourier transform, Laplace transform) is useful but not required.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to classify and describe signals and linear time-invariant (LTI) systems using methods of signal and system theory. They are able to apply the fundamental transformations of continuous-time and discrete-time signals and systems. They can describe and analyse deterministic signals and systems mathematically in both time and image domain. In particular, they understand the effects in time domain and image domain which are caused by the transition of a continuous-time signal to a discrete-time signal. The students are familiar with the contents of lecture and tutorials. They can explain and apply them to new problems.
Skills	The students are able to describe and analyse deterministic signals and linear time-invariant systems using methods of signal and system theory. They can analyse and design basic systems regarding important properties such as magnitude and phase response, stability, linearity etc.. They can assess the impact of LTI systems on the signal properties in time and frequency domain.
Personal Competence	
Social Competence	The students can jointly solve specific problems.
Autonomy	The students are able to acquire relevant information from appropriate literature sources. They can control their level of knowledge during the lecture period by solving tutorial problems, software tools, clicker system.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory Data Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Mechanical Engineering: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0432: Signals and Systems

Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Gerhard Bauch
Language	DE/EN
Cycle	SoSe

Content	• Introduction to signal and system theory
	• Signals
	  ◦ Classification of signals
	  ▪ Continuous-time and discrete-time signals
	  ▪ Analog and digital signals
	  ▪ Deterministic and random signals
	  ◦ Description of LTI systems by differential equations or difference equations, respectively
	  ◦ Basic properties of signals and operations on signals
	  ◦ Elementary signals
	  ◦ Distributions (Generalized Functions)
	  ◦ Power and energy of signals
	  ◦ Correlation functions of deterministic signals
	  ▪ Autocorrelation function
	  ▪ Crosscorrelation function
	  ▪ Orthogonal signals
	  ▪ Applications of correlation
	• Linear time-invariant (LTI) systems

	◦ Linearity ◦ Time-invariance ◦ Description of LTI systems by impulse response and frequency response ◦ Convolution ◦ Convolution and correlation ◦ Properties of LTI-systems ◦ Causal systems ◦ Stable systems ◦ Memoryless systems • Fourier Series and Fourier Transform ◦ Fourier transform of continuous-time signals, discrete-time signals, periodic signals, non-periodic signals ◦ Properties of the Fourier transform ◦ Fourier transform of some basic signals ◦ Parseval's theorem • Analysis of LTI-systems and signals in the frequency domain ◦ Frequency response, magnitude response and phase response ◦ Transmission factor, attenuation, gain ◦ Frequency-flat and frequency-selective LTI-systems ◦ Bandwidth definitions ◦ Basic types of systems (filters), lowpass, highpass, bandpass, bandstop systems ◦ Phase delay and group delay ◦ Linear-phase systems ◦ Distortion-free systems ◦ Spectrum analysis with limited observation window: Leakage effect • Laplace Transform ◦ Relation of Fourier transform and Laplace transform ◦ Properties of the Laplace transform ◦ Laplace transform of some basic signals • Analysis of LTI-systems in the s-domain ◦ Transfer function of LTI-systems ◦ Relation of Laplace transform, magnitude response and phase response ◦ Analysis of LTI-systems using pole-zero plots ◦ Allpass filters ◦ Minimum-phase, maximum-phase and mixed phase filters ◦ Stable systems • Sampling ◦ Sampling theorem ◦ Reconstruction of continuous-time signals in frequency domain and time domain ◦ Oversampling ◦ Aliasing ◦ Sampling with pulses of finite duration, sample and hold ◦ Decimation and interpolation • Discrete-Time Fourier Transform (DTFT) ◦ Relation of Fourier transform and DTFT ◦ Properties of the DTFT • Discrete Fourier Transform (DFT) ◦ Relation of DTFT and DFT ◦ Cyclic properties of the DFT ◦ DFT matrix ◦ Zero padding ◦ Cyclic convolution ◦ Fast Fourier Transform (FFT) ◦ Application of the DFT: Orthogonal Frequency Division Multiplex (OFDM) • Z-Transform ◦ Relation of Laplace transform, DTFT, and z-transform ◦ Properties of the z-transform ◦ Z-transform of some basic discrete-time signals • Discrete-time systems, digital filters ◦ FIR and IIR filters ◦ Z-transform of digital filters ◦ Analysis of discrete-time systems using pole-zero plots in the z-domain ◦ Stability ◦ Allpass filters ◦ Minimum-phase, maximum-phase and mixed-phase filters ◦ Linear phase filters
Literature	• T. Frey , M. Bossert , Signal- und Systemtheorie, B.G. Teubner Verlag 2004 • K. Kammeyer, K. Kroschel, Digitale Signalverarbeitung, Teubner Verlag. • B. Girod ,R. Rabensteiner , A. Stenger , Einführung in die Systemtheorie, B.G. Teubner, Stuttgart, 1997 • J.R. Ohm, H.D. Lüke , Signalübertragung, Springer-Verlag 8. Auflage, 2002 • S. Haykin, B. van Veen: Signals and systems. Wiley. • Oppenheim, A.S. Willsky: Signals and Systems. Pearson.

	• Oppenheim, R. W. Schafer: Discrete-time signal processing. Pearson.

Course L0433: Signals and Systems	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Gerhard Bauch
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0734: Electrical Engineering Project Laboratory

Courses

Title	Typ	Hrs/wk	CP
Electrical Engineering Project Laboratory (L0640)	Project-/problem-based Learning	8	6

Module Responsible	Prof. Christian Becker
Admission Requirements	None
Recommended Previous Knowledge	Electrical Engineering I, Electrical Engineering II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to give a summary of the technical details of projects in the area of electrical engineering and illustrate respective relationships. They are capable of describing and communicating relevant problems and questions using appropriate technical language. They can explain the typical process of solving practical problems and present related results.
Skills	The students can transfer their fundamental knowledge on electrical engineering to the process of solving practical problems. They identify and overcome typical problems during the realization of projects in the context of electrical engineering. Students are able to develop, compare, and choose conceptual solutions for non-standardized problems.
Personal Competence	
Social Competence	Students are able to cooperate in small, mixed-subject groups in order to independently derive solutions to given problems in the context of electrical engineering. They are able to effectively present and explain their results alone or in groups in front of a qualified audience. Students have the ability to develop alternative approaches to an electrical engineering problem independently or in groups and discuss advantages as well as drawbacks.
Autonomy	Students are capable of independently solving electrical engineering problems using provided literature. They are able to fill gaps in as well as extent their knowledge using the literature and other sources provided by the supervisor. Furthermore, they can meaningfully extend given problems and pragmatically solve them by means of corresponding solutions and concepts.
Workload in Hours	Independent Study Time 68, Study Time in Lecture 112
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	based on task + presentation
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory Electrical Engineering: Core Qualification: Compulsory Engineering Science: Specialisation Electrical Engineering: Compulsory Engineering Science: Specialisation Electrical Engineering: Elective Compulsory Engineering Science: Specialisation Electrical Engineering: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0640: Electrical Engineering Project Laboratory	
Typ	Project-/problem-based Learning
Hrs/wk	8
CP	6
Workload in Hours	Independent Study Time 68, Study Time in Lecture 112
Lecturer	Prof. Christian Becker, Dozenten des SD E
Language	DE
Cycle	SoSe
Content	Topics and projects cover the entire field of applications of electrical engineering. Typically, the students will prototype functional units and self-contained systems, such as radar devices, networks of sensors, amateur radio transceiver, power electronics based inverters, discrete computers, or atomic force microscopes. Different projects are devised on a yearly basis.
Literature	Alle zur Durchführung der Projekte sinnvollen Quellen (Skripte, Fachbücher, Manuals, Datenblätter, Internetseiten). / All sources that are useful for completion of the projects (lecture notes, textbooks, manuals, data sheets, internet pages).

Module M0854: Mathematics IV

Courses

Title	Typ	Hrs/wk	CP
Differential Equations 2 (Partial Differential Equations) (L1043)	Lecture	2	1
Differential Equations 2 (Partial Differential Equations) (L1044)	Recitation Section (small)	1	1
Differential Equations 2 (Partial Differential Equations) (L1045)	Recitation Section (large)	1	1
Complex Functions (L1038)	Lecture	2	1
Complex Functions (L1041)	Recitation Section (small)	1	1
Complex Functions (L1042)	Recitation Section (large)	1	1

Module Responsible	Prof. Marko Lindner
Admission Requirements	None
Recommended Previous Knowledge	Mathematics I - III
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name the basic concepts in Mathematics IV. They are able to explain them using appropriate examples. • Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples. • They know proof strategies and can reproduce them.
Skills	• Students can model problems in Mathematics IV with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods. • Students are able to discover and verify further logical connections between the concepts studied in the course. • For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.
Personal Competence	
Social Competence	• Students are able to work together in teams. They are capable to use mathematics as a common language. • In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.
Autonomy	• Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them. • Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.
Workload in Hours	Independent Study Time 68, Study Time in Lecture 112
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min (Complex Functions) + 60 min (Differential Equations 2)
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory Electrical Engineering: Core Qualification: Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Mechanical Engineering: Specialisation Mechatronics: Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Elective Compulsory Mechatronics: Core Qualification: Compulsory Naval Architecture: Core Qualification: Compulsory Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory

Course L1043: Differential Equations 2 (Partial Differential Equations)	
Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	Main features of the theory and numerical treatment of partial differential equations • Examples of partial differential equations • First order quasilinear differential equations • Normal forms of second order differential equations • Harmonic functions and maximum principle • Maximum principle for the heat equation • Wave equation • Liouville's formula • Special functions • Difference methods • Finite elements
Literature	• http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html

Course L1044: Differential Equations 2 (Partial Differential Equations)	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1045: Differential Equations 2 (Partial Differential Equations)	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1038: Complex Functions	
Typ	Lecture
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	Main features of complex analysis • Functions of one complex variable • Complex differentiation • Conformal mappings • Complex integration • Cauchy's integral theorem • Cauchy's integral formula • Taylor and Laurent series expansion • Singularities and residuals • Integral transformations: Fourier and Laplace transformation
Literature	• http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html

Course L1041: Complex Functions	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1042: Complex Functions	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1340: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility

Courses

Title	Typ	Hrs/wk	CP
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1669)	Lecture	3	4
Introduction to Waveguides, Antennas, and Electromagnetic Compatibility (L1877)	Recitation Section (small)	2	2

Module Responsible	Prof. Christian Schuster
Admission Requirements	None
Recommended Previous Knowledge	Basic principles of physics and electrical engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can explain the basic principles, relationships, and methods for the design of waveguides and antennas as well as of Electromagnetic Compatibility. Specific topics are: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Fundamental properties and phenomena of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - Radiation and basic antenna parameters - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques
Skills	Students know how to apply various methods and models for characterization and choice of waveguides and antennas. They are able to assess and qualify their basic electromagnetic properties. They can apply results and strategies from the field of Electromagnetic Compatibilty to the development of electrical components and systems.
Personal Competence	
Social Competence	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively in English (e.g. during small group exercises).
Autonomy	Students are capable to gather information from subject related, professional publications and relate that information to the context of the lecture. They are able to make a connection between their knowledge obtained in this lecture with the content of other lectures (e.g. theory of electromagnetic fields, fundamentals of electrical engineering / physics). They can discuss technical problems and physical effects in English.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	45 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Engineering Science: Specialisation Electrical Engineering: Elective Compulsory Engineering Science: Specialisation Electrical Engineering: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Aeronautics: Core Qualification: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory

Course L1669: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	This course is intended as an introduction to the topics of wave propagation, guiding, sending, and receiving as well as Electromagnetic Compatibility (EMC). It will be useful for engineers that face the technical challenge of transmitting high frequency / high bandwidth data in e.g. medical, automotive, or avionic applications. Both circuit and field concepts of wave propagation and Electromagnetic Compatibility will be introduced and discussed. Topics: - Fundamental properties and phenomena of electrical circuits - Steady-state sinusoidal analysis of electrical circuits - Fundamental properties and phenomena of electromagnetic fields and waves - Steady-state sinusoidal description of electromagnetic fields and waves - Useful microwave network parameters - Transmission lines and basic results from transmission line theory - Plane wave propagation, superposition, reflection and refraction - General theory of waveguides - Most important types of waveguides and their properties - Radiation and basic antenna parameters - Most important types of antennas and their properties - Numerical techniques and CAD tools for waveguide and antenna design - Fundamentals of Electromagnetic Compatibility - Coupling mechanisms and countermeasures - Shielding, grounding, filtering - Standards and regulations - EMC measurement techniques
Literature	- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999) - J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012) - D. M. Pozar, "Microwave Engineering", Wiley (2011) - Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008) - H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009) - A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)

Course L1877: Introduction to Waveguides, Antennas, and Electromagnetic Compatibility	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Schuster
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1962: Basics space electronics and primary mission

Courses

Title	Typ	Hrs/wk	CP
Basics space electronics and primary mission (L3204)	Project-/problem-based Learning	4	6

Module Responsible	Prof. Ulf Kulau
Admission Requirements	None
Recommended Previous Knowledge	• Electrical engineering / Fundamentals of electrical engineering • Computer science / Computer science for engineers
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Fundamentals of space electronics, • Subcomponents of satellite systems • Fragmentation and planning of primary missions • Active participation in CubeSat mission to apply learned skills • Soft skills in project management, project planning and project communication
Skills	Upon completion of the module, students will have learned fundamentals of space electronics. They also know how to plan primary missions and how to define subsystems to achieve this primary mission (requirements analysis, performance specification). They will be actively involved in missions and will be expected to put what they have learned into practice there. Additional soft skills in the area of general project management will be taught and applied through collaboration with the students. • Basic teaching • Conceptual design of subsystems (description of requirements and services) • Project planning and fragmentation of primary missions (space missions) • Practical application in CubeSat mission
Personal Competence	
Social Competence	The work takes place alternately in the entire group, but also in small groups. This requires close cooperation and coordination within the individual teams. The goal is for students to gain a sound knowledge of space electronics and space missions on the one hand, to apply this knowledge on the other hand and to generate sustainability of their results by working in small groups. This can be, for example, the passing on of the requirement and performance specifications, which act as a basis, starting point and result across semesters.
Autonomy	After completing the module, students will be able to independently plan and carry out scientific projects and processes. In group work, organization, idea generation, derivation of hypotheses and thought processes are to be independently moderated and carried out.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Report on achieved results
Assignment for the Following Curricula	Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory

Course L3204: Basics space electronics and primary mission

Typ	Project-/problem-based Learning
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Ulf Kulau
Language	DE/EN
Cycle	WiSe/SoSe
Content	
Literature	

Module M0834: Computernetworks and Internet Security

Courses

Title	Typ	Hrs/wk	CP
Computer Networks and Internet Security (L1098)	Lecture	3	5
Computer Networks and Internet Security (L1099)	Recitation Section (small)	1	1

Module Responsible	Prof. Andreas Timm-Giel
Admission Requirements	None
Recommended Previous Knowledge	Basics of Computer Science
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to explain important and common Internet protocols in detail and classify them, in order to be able to analyse and develop networked systems in further studies and job.
Skills	Students are able to analyse common Internet protocols and evaluate the use of them in different domains.
Personal Competence	
Social Competence	
Autonomy	Students can select relevant parts out of high amount of professional knowledge and can independently learn and understand it.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Elective Compulsory Computer Science: Core Qualification: Compulsory Data Science: Specialisation I. Mathematics/Computer Science: Elective Compulsory Data Science: Core Qualification: Elective Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Engineering Science: Specialisation Mechatronics: Elective Compulsory Engineering Science: Specialisation Electrical Engineering: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechatronics: Elective Compulsory Computer Science in Engineering: Core Qualification: Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory

Course L1098: Computer Networks and Internet Security	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Dr.-Ing. Koojana Kuladinithi, Prof. Sibylle Fröschle
Language	EN
Cycle	WiSe
Content	In this class an introduction to computer networks with focus on the Internet and its security is given. Basic functionality of complex protocols are introduced. Students learn to understand these and identify common principles. In the exercises these basic principles and an introduction to performance modelling are addressed using computing tasks and physical labs. In the second part of the lecture an introduction to Internet security is given. This class comprises: • Introduction to the Internet (TCP/IP model) • Application layer protocols (HTTP, SMTP, DNS) • Transport layer protocols (TCP, UDP) • Network Layer (Internet Protocol IPv4 & IPv6, routing in the Internet) • Data link layer with media access at the example of WLAN • Introduction to Internet Security • Security Aspects of Address Resolution (DNS/DNSSEC, ARP/SEND • Communication Security (IPSec) - From Address Resolution to Routing (Securing BGP) • Botnets + Firewalls
Literature	• Kurose, Ross, Computer Networking - A Top-Down Approach, 8th Edition, Addison-Wesley • Kurose, Ross, Computernetzwerke - Der Top-Down-Ansatz, Pearson Studium; Auflage: 8. Auflage • W. Stallings: Cryptography and Network Security: Principles and Practice, 6th edition Further literature is announced at the beginning of the lecture.

Course L1099: Computer Networks and Internet Security	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr.-Ing. Koojana Kuladinithi, Prof. Sibylle Fröschle
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0568: Theoretical Electrical Engineering II: Time-Dependent Fields

Courses

Title	Typ	Hrs/wk	CP
Theoretical Electrical Engineering II: Time-Dependent Fields (L0182)	Lecture	3	5
Theoretical Electrical Engineering II: Time-Dependent Fields (L0183)	Recitation Section (small)	2	1

Module Responsible	Prof. Christian Schuster
Admission Requirements	None
Recommended Previous Knowledge	Electrical Engineering I, Electrical Engineering II, Theoretical Electrical Engineering I Mathematics I, Mathematics II, Mathematics III, Mathematics IV
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to explain fundamental formulas, relations, and methods related to the theory of time-dependent electromagnetic fields. They can assess the principal behavior and characteristics of quasistationary and fully dynamic fields with regard to respective sources. They can describe the properties of complex electromagnetic fields by means of superposition of solutions for simple fields. The students are aware of applications for the theory of time-dependent electromagnetic fields and are able to explicate these.
Skills	Students are able to apply a variety of procedures in order to solve the diffusion and the wave equation for general time-dependent field problems. They can assess the principal effects of given time-dependent sources of fields and analyze these quantitatively. They can deduce meaningful quantities for the characterization of fully dynamic fields (wave impedance, skin depth, Poynting-vector, radiation resistance, etc.) from given fields and interpret them with regard to practical applications.
Personal Competence	
Social Competence	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively (e.g. during exercise sessions).
Autonomy	Students are capable to gather necessary information from provided references and relate this information to the lecture. They are able to continually reflect their knowledge by means of activities that accompany the lecture, such as short oral quizzes during the lectures and exercises that are related to the exam. Based on respective feedback, students are expected to adjust their individual learning process. They are able to draw connections between acquired knowledge and ongoing research at the Hamburg University of Technology (TUHH), e.g. in the area of high frequency engineering and optics.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90-150 minutes
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory Electrical Engineering: Core Qualification: Compulsory Engineering Science: Specialisation Electrical Engineering: Compulsory Engineering Science: Specialisation Mechatronics: Elective Compulsory Mechatronics: Specialisation Electrical Systems: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0182: Theoretical Electrical Engineering II: Time-Dependent Fields	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Prof. Christian Schuster
Language	DE
Cycle	WiSe
Content	- Theory and principal characteristics of quasistationary electromagnetic fields - Electromagnetic induction and law of induction - Skin effect and eddy currents - Shielding of time variable magnetic fields - Theory and principal characteristics of fully dynamic electromagnetic fields - Wave equations and properties of planar waves - Polarization and superposition of planar waves - Reflection and refraction of planar waves at boundary surfaces - Waveguide theory - Rectangular waveguide, planar optical waveguide - Elektrical and magnetical dipol radiation - Simple arrays of antennas The practical application of numerical methods will be trained within specifically prepared lectures in an interactive manner using small MATLAB programs.
Literature	- G. Lehner, "Elektromagnetische Feldtheorie: Für Ingenieure und Physiker", Springer (2010) - H. Henke, "Elektromagnetische Felder: Theorie und Anwendung", Springer (2011) - W. Nolting, "Grundkurs Theoretische Physik 3: Elektrodynamik", Springer (2011) - D. Griffiths, "Introduction to Electrodynamics", Pearson (2012) - J. Edminister, "Schaum's Outline of Electromagnetics", Mcgraw-Hill (2013) - Richard Feynman, "Feynman Lectures on Physics: Volume 2", Basic Books (2011)

Course L0183: Theoretical Electrical Engineering II: Time-Dependent Fields	
Typ	Recitation Section (small)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Christian Schuster
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1235: Electrical Power Systems I: Introduction to Electrical Power Systems

Courses

Title	Typ	Hrs/wk	CP
Electrical Power Systems I: Introduction to Electrical Power Systems (L1670)	Lecture	3	4
Electrical Power Systems I: Introduction to Electrical Power Systems (L1671)	Recitation Section (small)	2	2

Module Responsible	Prof. Christian Becker
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of Electrical Engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to give an overview of conventional and modern electric power systems. They can explain in detail and critically evaluate technologies of electric power generation, transmission, storage, and distribution as well as integration of equipment into electric power systems.
Skills	With completion of this module the students are able to apply the acquired skills in applications of the design, integration, development of electric power systems and to assess the results.
Personal Competence	
Social Competence	The students can participate in specialized and interdisciplinary discussions, advance ideas and represent their own work results in front of others.
Autonomy	Students can independently tap knowledge of the emphasis of the lectures.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 - 150 minutes
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory Data Science: Core Qualification: Elective Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Energy Systems: Specialisation Energy Systems: Elective Compulsory Engineering Science: Specialisation Electrical Engineering: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Integrated Building Technology: Core Qualification: Compulsory Mechatronics: Specialisation Electrical Systems: Elective Compulsory Renewable Energies: Core Qualification: Compulsory Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory

Course L1670: Electrical Power Systems I: Introduction to Electrical Power Systems	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe

Content	• fundamentals and current development trends in electric power engineering
	• tasks and history of electric power systems
	• symmetric three-phase systems
	• fundamentals and modelling of eletric power systems
	  ◦ lines
	  ◦ transformers
	  ◦ synchronous machines
	  ◦ induction machines
	  ◦ loads and compensation
	  ◦ grid structures and substations
	• fundamentals of energy conversion
	  ◦ electro-mechanical energy conversion
	  ◦ thermodynamics
	  ◦ power station technology
	  ◦ renewable energy conversion systems
	• steady-state network calculation
	  ◦ network modelling
	  ◦ load flow calculation
	  ◦ (n-1)-criterion
	• symmetric failure calculations, short-circuit power
	• control in networks and power stations
	• grid protection
	• grid planning
	• power economy fundamentals

Literature	K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013 A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017 R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008

Course L1671: Electrical Power Systems I: Introduction to Electrical Power Systems	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Becker
Language	DE
Cycle	WiSe

Content	• fundamentals and current development trends in electric power engineering
	• tasks and history of electric power systems
	• symmetric three-phase systems
	• fundamentals and modelling of eletric power systems
	  ◦ lines
	  ◦ transformers
	  ◦ synchronous machines
	  ◦ induction machines
	  ◦ loads and compensation
	  ◦ grid structures and substations
	• fundamentals of energy conversion
	  ◦ electro-mechanical energy conversion
	  ◦ thermodynamics
	  ◦ power station technology
	  ◦ renewable energy conversion systems
	• steady-state network calculation
	  ◦ network modelling
	  ◦ load flow calculation
	  ◦ (n-1)-criterion
	• symmetric failure calculations, short-circuit power
	• control in networks and power stations
	• grid protection
	• grid planning
	• power economy fundamentals

Literature	K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013 A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017 R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008

Module M0662: Numerical Mathematics I

Courses

Title	Typ	Hrs/wk	CP
Numerical Mathematics I (L0417)	Lecture	2	3
Numerical Mathematics I (L0418)	Recitation Section (small)	2	3

Module Responsible	Prof. Sabine Le Borne
Admission Requirements	None
Recommended Previous Knowledge	• Mathematik I + II for Engineering Students (german or english) **or** Analysis & Linear Algebra I + II for Technomathematicians • basic MATLAB/Python knowledge
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to • name numerical methods for interpolation, integration, least squares problems, eigenvalue problems, nonlinear root finding problems and to explain their core ideas, • repeat convergence statements for the numerical methods, • explain aspects for the practical execution of numerical methods with respect to computational and storage complexitx.
Skills	Students are able to • implement, apply and compare numerical methods using MATLAB/Python, • justify the convergence behaviour of numerical methods with respect to the problem and solution algorithm, • select and execute a suitable solution approach for a given problem.
Personal Competence	
Social Competence	Students are able to • work together in heterogeneously composed teams (i.e., teams from different study programs and background knowledge), explain theoretical foundations and support each other with practical aspects regarding the implementation of algorithms.
Autonomy	Students are capable • to assess whether the supporting theoretical and practical excercises are better solved individually or in a team, • to assess their individual progess and, if necessary, to ask questions and seek help.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 minutes
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory General Engineering Science (German program, 7 semester): Specialisation Data Science: Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Data Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Engineering Science: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory Computer Science in Engineering: Core Qualification: Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Mechanical Engineering: Specialisation Mechatronics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0417: Numerical Mathematics I	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Sabine Le Borne
Language	EN
Cycle	WiSe
Content	1. Finite precision arithmetic, error analysis, conditioning and stability 2. Linear systems of equations: LU and Cholesky factorization, condition 3. Interpolation: polynomial, spline and trigonometric interpolation 4. Nonlinear equations: fixed point iteration, root finding algorithms, Newton's method 5. Linear and nonlinear least squares problems: normal equations, Gram Schmidt and Householder orthogonalization, singular value decomposition, regularizatio, Gauss-Newton and Levenberg-Marquardt methods 6. Eigenvalue problems: power iteration, inverse iteration, QR algorithm 7. Numerical differentiation 8. Numerical integration: Newton-Cotes rules, error estimates, Gauss quadrature, adaptive quadrature
Literature	• Gander/Gander/Kwok: Scientific Computing: An introduction using Maple and MATLAB, Springer (2014) • Stoer/Bulirsch: Numerische Mathematik 1, Springer • Dahmen, Reusken: Numerik für Ingenieure und Naturwissenschaftler, Springer

Course L0418: Numerical Mathematics I	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Sabine Le Borne, Dr. Jens-Peter Zemke
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0675: Introduction to Communications and Random Processes

Courses

Title	Typ	Hrs/wk	CP
Introduction to Communications and Random Processes (L0442)	Lecture	3	4
Introduction to Communications and Random Processes (L0443)	Recitation Section (large)	1	1
Introduction to Communications and Random Processes (L2354)	Recitation Section (small)	1	1

Module Responsible	Prof. Gerhard Bauch
Admission Requirements	None
Recommended Previous Knowledge	• Mathematics 1-3 • Signals and Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students know and understand the fundamental building blocks of a communications system. They can describe and analyse the individual building blocks using knowledge of signal and system theory as well as the theory of stochastic processes. The are aware of the essential resources and evaluation criteria of information transmission and are able to design and evaluate a basic communications system. The students are familiar with the contents of lecture and tutorials. They can explain and apply them to new problems.
Skills	The students are able to design and evaluate a basic communications system. In particular, they can estimate the required resources in terms of bandwidth and power. They are able to assess essential evaluation parameters of a basic communications system such as bandwidth efficiency or bit error rate and to decide for a suitable transmission method.
Personal Competence	
Social Competence	The students can jointly solve specific problems.
Autonomy	The students are able to acquire relevant information from appropriate literature sources. They can control their level of knowledge during the lecture period by solving tutorial problems, software tools, clicker system.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory Data Science: Core Qualification: Elective Compulsory Data Science: Specialisation I. Mathematics/Computer Science: Elective Compulsory Electrical Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Mechatronics: Specialisation Electrical Systems: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0442: Introduction to Communications and Random Processes

Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Gerhard Bauch
Language	DE/EN
Cycle	WiSe

Content	• Introduction to communications engineering
	• Open Systems Interconnection (OSI) reference model
	• Components of a digital communications system
	• Fundamentals of signals and systems
	  ◦ Analog and digital signals
	  ◦ Principles of Analog-to-digital (A/D) conversion
	  ◦ Deterministic and random signals
	  ◦ Power and energy of signals
	  ◦ Linear time-invariant (LTI) systems
	  ◦ Quadrature amplitude modulation (QAM)
	• Introduction to stochastics
	• Probability theory
	  ◦ Random experiments
	  ◦ Probability model, probability space, sample space
	  ◦ Definitions of probability
	  ▪ Probability according to Bernoulli/Laplace
	  ▪ Probability according to van Mises, relative frequency
	  ▪ Bertrand's paradox
	  ▪ Axiomatic definition of probability according to Kolmogorov
	  ▪ Probability of disjoint and non-disjoint events
	  ▪ Venn diagrams

- Continuous and discrete random variables
  - Probability density function (pdf), cululative distribution function (cdf)
  - Expected value, mean, median, quadratic mean, variance, standard deviation, higher moments
  - Examples for probability distributions (Bernoulli distribution, two-point distribution, uniform distribution, Gaussian (normal) distribution, Rayleigh distribution, etc.)
- Multiple random variables
  - Conditional probability, joint probability
  - Conditional and joint probability density function
  - Bayes' rule
  - Correlation coefficient
  - Two-dimensional Gaussian distribution
  - Statistically independent, uncorrelated and orthogonal random variables
  - Independent identically distributed (iid) random variables
  - Properties of expected value and variance
  - Covariance
  - Probability density function (pdf) and cumulative distribution function (cdf) of the sum of statistically independent random variables
  - Central limit theorem
- Probability density functions (pdfs) in data transmission

- Continuous-time and discrete-time random processes
  - Examples for random processes
  - Ensemble average and time average
  - Ergodic random processes
  - Quadratic mean and variance
  - Probability density function (pdf) and cumulative distribution function (cdf)
  - Joint probability density function (pdf) and joint cumulative distribution function (cdf)
  - Statistically independent, uncorrelated and orthogonal random processes
  - Stationary random processes
  - Correlation functions: Autocorrelation function, crosscorrelation function, average autocorrelation function of non-stationary random processes, autocorrelation and crosscorrelation function of stationary processes, autocovariance function, crosscovariance function
  - Autocorrelation matrix, crosscorrelation matrix, autocovariance matrix, crosscovariance matrix
  - Pseudo-noise sequences, example: Code division multiple access (CDMA)
  - Autocorrelation function, power spectral density (psd), signal power, Einstein-Wiener-Khintchine relations
  - White (Gaussian) noise
- Filtering of random processes by LTI systems
  - Transformation of the probability density function (pdf)
  - Transformation of the mean
  - Transformation of the power spectral density (psd)
  - Correlation functions of input and output signal
  - Filtering of white Gaussian noise
  - Bandlimitation for noise power limitation
  - Preemphasis and deemphasis
- Companding, mu-law, A-law
- Functions of random variables
  - Transformation of probabilities and of the probability density function (pdf)
  - Application: Non-linear amplifiers
- Functions of two random variables
  - Probability density function
  - Examples: Rayleigh distribution, magnitude of an OFDM signal, magnitude of a received radio signal
- Transmission channels and channel models
  - Wireline channels: Telephone cable, coaxial cable, optical fiber
  - Wireless channels: Fading radio channel, underwater channels
  - Frequency-flat and frequency-selective channels
  - Additive white Gaussian noise (AWGN) channel
  - Signal to noise power ratio (SNR)
  - Discrete-time channel models
  - Discrete memoryless channels (DMC)
- Analog-to-digital conversion
  - Sampling
    - Sampling theorem
  - Pulse modulation
    - Pulse-amplitude modulation (PAM)
    - Pulse-duration modulation (PDM), pulse-width modulation (PWM)
    - Pulse-position modulation (PPM)
    - Pulse-code modulation (PCM)
  - Quantization
    - Linear quantizaton, midtread and midrise characteristic
    - Quantization error, quantization noise
    - Signal-to-quantization noise ratio
    - Non-linear quantization, compressor characteristics, mu-law, A-law
    - Speech transmission with PCM
  - Differential pulse-code modulation (DPCM)
    - Linear prediction according to the minimum mean squared error (MMSE) criterion.
    - DPCM with forward prediction and backward prediction

	▪ SNR gain of DPCM over PCM ▪ Delta modulation • Fundamentals of information theory and coding ◦ Definitions of information: Self-information, entropy ◦ Binary entropy function ◦ Source coding theorem ◦ Source coding: Huffman code ◦ Mutual information and channel capacity ◦ Channel capacity of the AWGN channel and the binary input AWGN channel ◦ Channel coding theorem ◦ Principles of channel coding: Code rate and data rate, Hamming distance, minimum Hamming distance, error detection and error correction ◦ Examples for channel codes: Block codes and convolutional codes, repetition code, single parity check code, Hamming code, Turbo codes • Combinatorics ◦ Variation with and without repetition ◦ Combination with and without repetition ◦ Permutation, Permutation of multisets ◦ Word error probabilities of linear block codes • Baseband transmission ◦ Pulse shaping: Non-return to zero (NRZ) rectangular pulses, Manchester pulses, raised-cosine pulses, square-root raised-cosine pulses, Gaussian pulses ◦ Transmit signal energy, average energy per symbol ◦ Power spectral density (psd) of baseband signals ◦ Definitions of signal bandwidth ◦ Bandwidth efficiency ◦ Intersymbol interference (ISI) ◦ First and second Nyquist criterion ◦ Eye patterns ◦ Receive filter design: Matched filter ◦ Matched-filter receiver and correlation receiver ◦ Square-root Nyquist pulse shaping ◦ Discrete-time AWGN channel model • Maximum a posteriori probability (MAP) and maximum likelihood (ML) detection • Bit error probability in AWGN channels for binary antipodal and on-off signaling • Band-pass transmission via carrier modulation ◦ Amplitude modulation, frequency modulation, phase modulation ◦ Linear digital modulation methods: On-off keying (OOK), phase-shift keying (PSK), amplitude shift keying (ASK), quadrature amplitude shift keying (QAM) •
Literature	K. Kammeyer: Nachrichtenübertragung, Teubner P.A. Höher: Grundlagen der digitalen Informationsübertragung, Teubner. M. Bossert: Einführung in die Nachrichtentechnik, Oldenbourg. J.G. Proakis, M. Salehi: Grundlagen der Kommunikationstechnik. Pearson Studium. J.G. Proakis, M. Salehi: Digital Communications. McGraw-Hill. S. Haykin: Communication Systems. Wiley J.G. Proakis, M. Salehi: Communication Systems Engineering. Prentice-Hall. J.G. Proakis, M. Salehi, G. Bauch, Contemporary Communication Systems. Cengage Learning.

Course L0443: Introduction to Communications and Random Processes	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Gerhard Bauch
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L2354: Introduction to Communications and Random Processes	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Gerhard Bauch
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1802: Engineering Mechanics I (Stereostatics)

Courses

Title	Typ	Hrs/wk	CP
Engineering Mechanics I (Statics) (L1001)	Lecture	2	3
Engineering Mechanics I (Statics) (L1003)	Recitation Section (large)	1	1
Engineering Mechanics I (Statics) (L1002)	Recitation Section (small)	2	2

Module Responsible	Prof. Benedikt Kriegesmann
Admission Requirements	None
Recommended Previous Knowledge	Solid school knowledge in mathematics and physics.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can • describe the axiomatic procedure used in mechanical contexts; • explain important steps in model design; • present technical knowledge in stereostatics.
Skills	The students can • explain the important elements of mathematical / mechanical analysis and model formation, and apply it to the context of their own problems; • apply basic statical methods to engineering problems; • estimate the reach and boundaries of statical methods and extend them to be applicable to wider problem sets.
Personal Competence	
Social Competence	The students can work in groups and support each other to overcome difficulties.
Autonomy	Students are capable of determining their own strengths and weaknesses and to organize their time and learning based on those.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Civil- and Environmental Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Data Science: Specialisation II. Application: Elective Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Integrated Building Technology: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory

Course L1001: Engineering Mechanics I (Statics)	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Benedikt Kriegesmann
Language	DE
Cycle	WiSe
Content	• Tasks in Mechanics • Modelling and model elements • Vector calculus for forces and torques • Forces and equilibrium in space • Constraints and reactions, characterization of constraint systems • Planar and spatial truss structures • Internal forces and moments for beams and frames • Center of mass, volumn, area and line • Computation of center of mass by intergals, joint bodies • Friction (sliding and sticking) • Friction of ropes
Literature	K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009). D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1. 11. Auflage, Springer (2011).

Course L1003: Engineering Mechanics I (Statics)	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Benedikt Kriegesmann
Language	DE
Cycle	WiSe
Content	Forces and equilibrium Constraints and reactions Frames Center of mass Friction Internal forces and moments for beams
Literature	K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009). D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1. 11. Auflage, Springer (2011).

Course L1002: Engineering Mechanics I (Statics)	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Benedikt Kriegesmann
Language	DE
Cycle	WiSe
Content	Forces and equilibrium Constraints and reactions Frames Center of mass Friction Internal forces and moments for beams
Literature	K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009). D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1. 11. Auflage, Springer (2011).

Module M0760: Electronic Devices

Courses

Title	Typ	Hrs/wk	CP
Electronic Devices (L0720)	Lecture	3	4
Electronic Devices (L0721)	Project-/problem-based Learning	2	2

Module Responsible	Prof. Hoc Khiem Trieu
Admission Requirements	None
Recommended Previous Knowledge	Atomic model and quantum theory, electrical currents in solid state materials, basics in solid-state physics Successful participation of Physics for Engineers and Materials in Electrical Engineering or courses with equivalent contents
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able • to represent the basics of semiconductor physics, • to explain the operating principle of important semiconductor devices, • to outline device characteristics and equivalent circuits as well as to explain their derivation and • to discuss the limitation of device models.
Skills	Students are capable • to apply devices in basic circuits, • to realize the physical context and to solve complex problems by oneself
Personal Competence	
Social Competence	Students are able to prepare and perform their lab experiments in team work as well as to present and discuss the results in front of audience.
Autonomy	Students are capable to acquire knowledge based on literature in order to prepare their experiments.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** Yes; **Bonus** 10 %; **Form** Subject theoretical and practical work; **Description** Studierenden erarbeiten in Kleingruppen Wissen zu einem bestimmten Thema, demonstrieren dieses in Form eines Versuches mit Präsentation und Diskussion. Darüber hinaus betreut jede Gruppe eine Übungsaufgabe, die inhaltlich zu dem jeweiligen Versuch gehört.
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory Electrical Engineering: Core Qualification: Compulsory Engineering Science: Specialisation Electrical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Mechatronics: Specialisation Electrical Systems: Compulsory

Course L0720: Electronic Devices	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Hoc Khiem Trieu
Language	DE
Cycle	WiSe
Content	• Uniformly doped semiconductor (semiconductor, crystal structure, energy band diagram, effective mass, density of state, probability of occupancy, mass action law, generation and recombination processes, generation and recombination lifetime, carrier transport mechanisms: drift current, diffusion current; equilibriums in semiconductor, semiconductor equations) • pn-junction (zero applied bias, energy band diagram in thermal equilibrium, current-voltage characteristics, derivation of diode equation, consideration of space charge recombination, transient behaviour, breakdown mechanisms, various types of diodes: Zener diode, tunnel diode, backward diode, photo diode, LED, laser diode) • Bipolar transistor (principle of operation, current-voltage characteristics: calculation of base, collector and emitter current, operating modes; non-ideality: actual doping profile, Early effect, breakdown, generation and recombination current and high injection; Ebers-Moll model: family of characteristics, equivalent circuit; frequency response, switching characteristics, heterojunction bipolar transistor) • Unipolar devices (surface effects: surface states, work function, energy band diagram; metal-semiconductor junctions: Schottky contact, current-voltage characteristics, ohmic contact; junction field effect transistor: operating principle, current-voltage characteristics, small-signal model, breakdown characteristics; MESFET: operating principle, depletion mode and enhancement mode MESFET; MIS structure: accumulation, depletion, inversion, strong inversion, flatband voltage, oxide charges, threshold voltage, capacitance voltage characteristics; MOSFET: basic structure, principle of operation, current voltage characteristics, frequency response, subthreshold behaviour, threshold voltage, device scaling; CMOS)
Literature	S.M. Sze: Semiconductor devices, Physics and Technology, John Wiley & Sons (1985)F. Thuselt: Physik der Halbleiterbauelemente, Springer (2011) T. Thille, D. Schmitt-Landsiedel: Mikroelektronik, Halbleiterbauelemente und deren Anwendung in elektronischen Schaltungen, Springer (2004) B.L. Anderson, R.L. Anderson: Fundamentals of Semiconductor Devices, McGraw-Hill (2005) D.A. Neamen: Semiconductor Physics and Devices, McGraw-Hill (2011) M. Shur: Introduction to Electronic Devices, John Wiley & Sons (1996) S.M. Sze: Physics of semiconductor devices, John Wiley & Sons (2007) H. Schaumburg: Halbleiter, B.G. Teubner (1991) A. Möschwitzer: Grundlagen der Halbleiter-&Mikroelektronik, Bd1 Elektronische Halbleiterbauelemente, Carl Hanser (1992) H.-G. Unger, W. Schultz, G. Weinhausen: Elektronische Bauelemente und Netzwerke I, Physikalische Grundlagen der Halbleiterbauelemente, Vieweg (1985)

Course L0721: Electronic Devices	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Hoc Khiem Trieu
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0833: Introduction to Control Systems

Courses

Title	Typ	Hrs/wk	CP
Introduction to Control Systems (L0654)	Lecture	2	4
Introduction to Control Systems (L0655)	Recitation Section (small)	2	2

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	Representation of signals and systems in time and frequency domain, Laplace transform
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can represent dynamic system behavior in time and frequency domain, and can in particular explain properties of first and second order systems • They can explain the dynamics of simple control loops and interpret dynamic properties in terms of frequency response and root locus • They can explain the Nyquist stability criterion and the stability margins derived from it. • They can explain the role of the phase margin in analysis and synthesis of control loops • They can explain the way a PID controller affects a control loop in terms of its frequency response • They can explain issues arising when controllers designed in continuous time domain are implemented digitally
Skills	• Students can transform models of linear dynamic systems from time to frequency domain and vice versa • They can simulate and assess the behavior of systems and control loops • They can design PID controllers with the help of heuristic (Ziegler-Nichols) tuning rules • They can analyze and synthesize simple control loops with the help of root locus and frequency response techniques • They can calculate discrete-time approximations of controllers designed in continuous-time and use it for digital implementation • They can use standard software tools (Matlab Control Toolbox, Simulink) for carrying out these tasks
Personal Competence	
Social Competence	Students can work in small groups to jointly solve technical problems, and experimentally validate their controller designs
Autonomy	Students can obtain information from provided sources (lecture notes, software documentation, experiment guides) and use it when solving given problems. They can assess their knowledge in weekly on-line tests and thereby control their learning progress.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Data Science: Core Qualification: Elective Compulsory Data Science: Specialisation II. Application: Elective Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Elective Compulsory Logistics and Mobility: Specialisation Information Technology: Elective Compulsory Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory

Course L0654: Introduction to Control Systems	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	WiSe
Content	Signals and systems • Linear systems, differential equations and transfer functions • First and second order systems, poles and zeros, impulse and step response • Stability Feedback systems • Principle of feedback, open-loop versus closed-loop control • Reference tracking and disturbance rejection • Types of feedback, PID control • System type and steady-state error, error constants • Internal model principle Root locus techniques • Root locus plots • Root locus design of PID controllers Frequency response techniques • Bode diagram • Minimum and non-minimum phase systems • Nyquist plot, Nyquist stability criterion, phase and gain margin • Loop shaping, lead lag compensation • Frequency response interpretation of PID control Time delay systems • Root locus and frequency response of time delay systems • Smith predictor Digital control • Sampled-data systems, difference equations • Tustin approximation, digital implementation of PID controllers Software tools • Introduction to Matlab, Simulink, Control toolbox • Computer-based exercises throughout the course
Literature	• Werner, H., Lecture Notes „Introduction to Control Systems“ • G.F. Franklin, J.D. Powell and A. Emami-Naeini "Feedback Control of Dynamic Systems", Addison Wesley, Reading, MA, 2009 • K. Ogata "Modern Control Engineering", Fourth Edition, Prentice Hall, Upper Saddle River, NJ, 2010 • R.C. Dorf and R.H. Bishop, "Modern Control Systems", Addison Wesley, Reading, MA 2010

Course L0655: Introduction to Control Systems	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	NN
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0634: Introduction into Medical Technology and Systems

Courses

Title	Typ	Hrs/wk	CP
Introduction into Medical Technology and Systems (L0342)	Lecture	2	3
Introduction into Medical Technology and Systems (L0343)	Project Seminar	2	2
Introduction into Medical Technology and Systems (L1876)	Recitation Section (large)	1	1

Module Responsible	Prof. Alexander Schlaefer
Admission Requirements	None
Recommended Previous Knowledge	principles of math (algebra, analysis/calculus) principles of stochastics principles of programming, R/Matlab
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can explain principles of medical technology, including imaging systems, computer aided surgery, and medical information systems. They are able to give an overview of regulatory affairs and standards in medical technology.
Skills	The students are able to evaluate systems and medical devices in the context of clinical applications.
Personal Competence	
Social Competence	The students describe a problem in medical technology as a project, and define tasks that are solved in a joint effort. The students can critically reflect on the results of other groups and make constructive suggestions for improvement.
Autonomy	The students can assess their level of knowledge and document their work results. They can critically evaluate the results achieved and present them in an appropriate manner.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	Compulsory: Yes; Bonus: 10 %; Form: Presentation Compulsory: Yes; Bonus: 10 %; Form: Written elaboration
Examination	Written exam
Examination duration and scale	90 minutes
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory Data Science: Specialisation II. Application: Elective Compulsory Data Science: Core Qualification: Elective Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Mechatronics: Specialisation Medical Engineering: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0342: Introduction into Medical Technology and Systems	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	DE
Cycle	SoSe
Content	- imaging systems - computer aided surgery - medical sensor systems - medical information systems - regulatory affairs - standard in medical technology The students will work in groups to apply the methods introduced during the lecture using problem based learning.
Literature	Bernhard Priem, "Visual Computing for Medicine", 2014 Heinz Handels, "Medizinische Bildverarbeitung", 2009 (https://katalog.tub.tuhh.de/Record/745558097) Valery Tuchin, "Tissue Optics - Light Scattering Methods and Instruments for Medical Diagnosis", 2015 Olaf Drössel, "Biomedizinische Technik - Medizinische Bildgebung", 2014 H. Gross, "Handbook of Optical Systems", 2008 (https://katalog.tub.tuhh.de/Record/856571687) Wolfgang Drexler, "Optical Coherence Tomography", 2008 Kramme, "Medizintechnik", 2011 Thorsten M. Buzug, "Computed Tomography", 2008 Otmar Scherzer, "Handbook of Mathematical Methods in Imaging", 2015 Weishaupt, "Wie funktioniert MRI?", 2014 Paul Suetens, "Fundamentals of Medical Imaging", 2009 Vorlesungsunterlagen

Course L0343: Introduction into Medical Technology and Systems	
Typ	Project Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1876: Introduction into Medical Technology and Systems	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Alexander Schlaefer
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1803: Engineering Mechanics II (Elastostatics)

Courses

Title	Typ	Hrs/wk	CP
Engineering Mechanics II (Elastostatics) (L0493)	Lecture	2	2
Engineering Mechanics II (Elastostatics) (L1691)	Recitation Section (large)	2	2
Engineering Mechanics II (Elastostatics) (L0494)	Recitation Section (small)	2	2

Module Responsible	Prof. Christian Cyron
Admission Requirements	None
Recommended Previous Knowledge	Engineering Mechanics I, Mathematics I (basic knowledge of rigid body mechanics such as balance of linear and angular momentum, basic knowledge of linear algebra like vector-matrix calculus, basic knowledge of analysis such as differential and integral calculus)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Having accomplished this module, the students know and understand the basic concepts of continuum mechanics and elastostatics, in particular stress, strain, constitutive laws, stretching, bending, torsion, failure analysis, energy methods and stability of structures.
Skills	Having accomplished this module, the students are able to - apply the fundamental concepts of mathematical and mechanical modeling and analysis to problems of their choice - apply the basic methods of elastostatics to problems of engineering, in particular in the design of mechanical structures - to educate themselves about more advanced aspects of elastostatics
Personal Competence	
Social Competence	Ability to communicate complex problems in elastostatics, to work out solution to these problems together with others, and to communicate these solutions.
Autonomy	Self-discipline and endurance in tackling independently complex challenges in elastostatics; ability to learn also very abstract knowledge.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Civil- and Environmental Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory

Course L0493: Engineering Mechanics II (Elastostatics)	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	SoSe
Content	The lecture Engineering Mechanics II introduces the fundamental concepts of stress and strain and explains how these can be used to characterize and compute elastic deformations of mechanical bodies under loading. The focus of the lecture lies on: • basis of continuum mechanics: stress, strain, constitutive laws • truss • torsion bar • beam theory: bending, moment of inertia of area, transverse shear • energy methods: Maxwell-Betti reciprocal work theorem, Castigliano's second theorem, theorem of Menabrea • strength of materials: maximum principle stress criterion, yield criteria according to Tresca and von Mises • stability of mechanical structures: Euler buckling strut
Literature	• Gross, D., Hauger, W., Schröder, J., Wall, W.A.: Technische Mechanik 1, Springer • Gross, D., Hauger, W., Schröder, J., Wall, W.A.: Technische Mechanik 2 Elastostatik, Springer

Course L1691: Engineering Mechanics II (Elastostatics)	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Course L0494: Engineering Mechanics II (Elastostatics)	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0777: Semiconductor Circuit Design

Courses

Title	Typ	Hrs/wk	CP
Semiconductor Circuit Design (L0763)	Lecture	3	4
Semiconductor Circuit Design (L0864)	Recitation Section (small)	1	2

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of electrical engineering Basics of physics, especially semiconductor physics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to explain the functionality of different MOS devices in electronic circuits. • Students are able to explain how analog circuits functions and where they are applied. • Students are able to explain the functionality of fundamental operational amplifiers and their specifications. • Students know the fundamental digital logic circuits and can discuss their advantages and disadvantages. • Students have knowledge about memory circuits and can explain their functionality and specifications. • Students know the appropriate fields for the use of bipolar transistors.
Skills	• Students can calculate the specifications of different MOS devices and can define the parameters of electronic circuits. • Students are able to develop different logic circuits and can design different types of logic circuits. • Students can use MOS devices, operational amplifiers and bipolar transistors for specific applications.
Personal Competence	
Social Competence	• Students are able work efficiently in heterogeneous teams. • Students working together in small groups can solve problems and answer professional questions.
Autonomy	• Students are able to assess their level of knowledge.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory Data Science: Core Qualification: Elective Compulsory Electrical Engineering: Core Qualification: Compulsory Engineering Science: Specialisation Electrical Engineering: Compulsory Engineering Science: Specialisation Mechatronics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechatronics: Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Mechanical Engineering: Specialisation Mechatronics: Compulsory Mechatronics: Specialisation Electrical Systems: Compulsory Mechatronics: Core Qualification: Compulsory Mechatronics: Specialisation Robot- and Machine-Systems: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0763: Semiconductor Circuit Design	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Matthias Kuhl
Language	DE
Cycle	SoSe
Content	• Repetition Semiconductorphysics and Diodes • Functionality and characteristic curve of bipolar transistors • Basic circuits with bipolar transistors • Functionality and characteristic curve of MOS transistors • Basic circuits with MOS transistors for amplifiers • Operational amplifiers and their applications • Typical applications for analog and digital circuits • Realization of logical functions • Basic circuits with MOS transistors for combinational logic • Memory circuits • Basic circuits with MOS transistors for sequential logic • Basic concepts of analog-to-digital and digital-to-analog-converters
Literature	U. Tietze und Ch. Schenk, E. Gamm, Halbleiterschaltungstechnik, Springer Verlag, 14. Auflage, 2012, ISBN 3540428496 R. J. Baker, CMOS - Circuit Design, Layout and Simulation, J. Wiley & Sons Inc., 3. Auflage, 2011, ISBN: 047170055S H. Göbel, Einführung in die Halbleiter-Schaltungstechnik, Berlin, Heidelberg Springer-Verlag Berlin Heidelberg, 2011, ISBN: 9783642208874 ISBN: 9783642208867 URL: http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10499499 URL: http://dx.doi.org/10.1007/978-3-642-20887-4 URL: http://ebooks.ciando.com/book/index.cfm/bok_id/319955 URL: http://www.ciando.com/img/bo

Course L0864: Semiconductor Circuit Design	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl, Weitere Mitarbeiter
Language	DE
Cycle	SoSe
Content	• Basic circuits and characteristic curves of bipolar transistors • Basic circuits and characteristic curves of MOS transistors for amplifiers • Realization and dimensioning of operational amplifiers • Realization of logic functions • Basic circuits with MOS transistors for combinational and sequential logic • Memory circuits • Circuits for analog-to-digital and digital-to-analog converters • Design of exemplary circuits
Literature	U. Tietze und Ch. Schenk, E. Gamm, Halbleiterschaltungstechnik, Springer Verlag, 14. Auflage, 2012, ISBN 3540428496 R. J. Baker, CMOS - Circuit Design, Layout and Simulation, J. Wiley & Sons Inc., 3. Auflage, 2011, ISBN: 047170055S H. Göbel, Einführung in die Halbleiter-Schaltungstechnik, Berlin, Heidelberg Springer-Verlag Berlin Heidelberg, 2011, ISBN: 9783642208874 ISBN: 9783642208867 URL: http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10499499 URL: http://dx.doi.org/10.1007/978-3-642-20887-4 URL: http://ebooks.ciando.com/book/index.cfm/bok_id/319955 URL: http://www.ciando.com/img/bo

Module M0803: Embedded Systems

Courses

Title	Typ	Hrs/wk	CP
Embedded Systems (L0805)	Lecture	3	3
Embedded Systems (L2938)	Project-/problem-based Learning	1	1
Embedded Systems (L0806)	Recitation Section (small)	1	2

Module Responsible	Prof. Heiko Falk
Admission Requirements	None
Recommended Previous Knowledge	Computer Engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Embedded systems can be defined as information processing systems embedded into enclosing products. This course teaches the foundations of such systems. In particular, it deals with an introduction into these systems (notions, common characteristics) and their specification languages (models of computation, hierarchical automata, specification of distributed systems, task graphs, specification of real-time applications, translations between different models). Another part covers the hardware of embedded systems: Sonsors, A/D and D/A converters, real-time capable communication hardware, embedded processors, memories, energy dissipation, reconfigurable logic and actuators. The course also features an introduction into real-time operating systems, middleware and real-time scheduling. Finally, the implementation of embedded systems using hardware/software co-design (hardware/software partitioning, high-level transformations of specifications, energy-efficient realizations, compilers for embedded processors) is covered.
Skills	After having attended the course, students shall be able to realize simple embedded systems. The students shall realize which relevant parts of technological competences to use in order to obtain a functional embedded systems. In particular, they shall be able to compare different models of computations and feasible techniques for system-level design. They shall be able to judge in which areas of embedded system design specific risks exist.
Personal Competence	
Social Competence	Students are able to solve similar problems alone or in a group and to present the results accordingly.
Autonomy	Students are able to acquire new knowledge from specific literature and to associate this knowledge with other classes.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** Yes; **Bonus** 10 %; **Form** Subject theoretical and practical work; **Description**
Examination	Written exam
Examination duration and scale	90 minutes, contents of course and labs
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory Computer Science: Specialisation I. Computer and Software Engineering: Elective Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Engineering Science: Specialisation Mechatronics: Elective Compulsory Engineering Science: Specialisation Electrical Engineering: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechatronics: Elective Compulsory Computer Science in Engineering: Core Qualification: Compulsory Aeronautics: Core Qualification: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Mechatronics: Specialisation Naval Engineering: Compulsory Mechatronics: Specialisation Electrical Systems: Compulsory Mechatronics: Specialisation Dynamic Systems and AI: Compulsory Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory Mechatronics: Specialisation Medical Engineering: Compulsory Microelectronics and Microsystems: Specialisation Embedded Systems: Elective Compulsory

Course L0805: Embedded Systems	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Heiko Falk
Language	EN
Cycle	SoSe
Content	• Introduction • Specifications and Modeling • Embedded/Cyber-Physical Systems Hardware • System Software • Evaluation and Validation • Mapping of Applications to Execution Platforms • Optimization
Literature	• Peter Marwedel. Embedded System Design - Embedded Systems Foundations of Cyber-Physical Systems. 2 nd Edition, Springer, 2012., Springer, 2012.

Course L2938: Embedded Systems	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Heiko Falk
Language	EN
Cycle	SoSe
Content	• Introduction • Specifications and Modeling • Embedded/Cyber-Physical Systems Hardware • System Software • Evaluation and Validation • Mapping of Applications to Execution Platforms • Optimization
Literature	• Peter Marwedel. Embedded System Design - Embedded Systems Foundations of Cyber-Physical Systems. 2 nd Edition, Springer, 2012., Springer, 2012.

Course L0806: Embedded Systems	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Heiko Falk
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Thesis

Module M-001: Bachelor Thesis

Courses

Title	Typ	Hrs/wk	CP

Module Responsible	Professoren der TUHH
Admission Requirements	• According to General Regulations §21 (1): At least 126 ECTS credit points have to be achieved in study programme. The examinations board decides on exceptions.
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• The students can select, outline and, if need be, critically discuss the most important scientific fundamentals of their course of study (facts, theories, and methods). • On the basis of their fundamental knowledge of their subject the students are capable in relation to a specific issue of opening up and establishing links with extended specialized expertise. • The students are able to outline the state of research on a selected issue in their subject area.
Skills	• The students can make targeted use of the basic knowledge of their subject that they have acquired in their studies to solve subject-related problems. • With the aid of the methods they have learnt during their studies the students can analyze problems, make decisions on technical issues, and develop solutions. • The students can take up a critical position on the findings of their own research work from a specialized perspective.
Personal Competence	
Social Competence	• Both in writing and orally the students can outline a scientific issue for an expert audience accurately, understandably and in a structured way. • The students can deal with issues in an expert discussion and answer them in a manner that is appropriate to the addressees. In doing so they can uphold their own assessments and viewpoints convincingly.
Autonomy	• The students are capable of structuring an extensive work process in terms of time and of dealing with an issue within a specified time frame. • The students are able to identify, open up, and connect knowledge and material necessary for working on a scientific problem. • The students can apply the essential techniques of scientific work to research of their own.
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0
Credit points	12
Course achievement	None
Examination	Thesis
Examination duration and scale	According to General Regulations
Assignment for the Following Curricula	General Engineering Science (German program): Thesis: Compulsory General Engineering Science (German program, 7 semester): Thesis: Compulsory Civil- and Environmental Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Data Science: Thesis: Compulsory Digital Mechanical Engineering: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Engineering Science: Thesis: Compulsory General Engineering Science (English program): Thesis: Compulsory General Engineering Science (English program, 7 semester): Thesis: Compulsory Green Technologies: Energy, Water, Climate: Thesis: Compulsory Computer Science in Engineering: Thesis: Compulsory Integrated Building Technology: Thesis: Compulsory Logistics and Mobility: Thesis: Compulsory Mechanical Engineering: Thesis: Compulsory Mechatronics: Thesis: Compulsory Naval Architecture: Thesis: Compulsory Technomathematics: Thesis: Compulsory Teilstudiengang Lehramt Metalltechnik: Thesis: Compulsory Process Engineering: Thesis: Compulsory Engineering and Management - Major in Logistics and Mobility: Thesis: Compulsory