



## **Module Manual**

Bachelor of Science (B.Sc.)

# **Electrical Engineering**

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## Program description

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### 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

## Module Manual B.Sc. "Electrical Engineering"

- 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	
<b>Module Responsible</b>	Dagmar Richter
<b>Admission Requirements</b>	None
<b>Recommended Previous Knowledge</b>	None
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results
<b>Professional Competence</b>	<p><i>Knowledge</i></p> <p><b>The Non-technical Academic Programms (NTA)</b></p> <p>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 <b>teaching architecture</b>, in its <b>teaching and learning arrangements</b>, in <b>teaching areas</b> and by means of teaching offerings in which students can qualify by opting for <b>specific competences</b> and a <b>competence level</b> at the Bachelor’s or Master’s level. The teaching offerings are pooled in two different catalogues for nontechnical complementary courses.</p> <p><b>The Learning Architecture</b></p> <p>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.</p> <p>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”</p> <p>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.</p> <p><b>Teaching and Learning Arrangements</b></p> <p>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.</p> <p><b>Fields of Teaching</b></p> <p>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.</p> <p>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.</p> <p><b>The Competence Level</b></p> <p>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.</p> <p>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.</p> <p><b>Specialized Competence (Knowledge)</b></p> <p>Students can</p> <ul style="list-style-type: none"> <li>• locate selected specialized areas with the relevant non-technical mother discipline,</li> <li>• outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area,</li> <li>• different specialist disciplines relate to their own discipline and differentiate it as well as make connections,</li> <li>• 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,</li> <li>• Can communicate in a foreign language in a manner appropriate to the subject.</li> </ul> <p><i>Skills</i></p> <p><b>Professional Competence (Skills)</b></p> <p>In selected sub-areas students can</p> <ul style="list-style-type: none"> <li>• apply basic methods of the said scientific disciplines,</li> <li>• auestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline,</li> <li>• to handle simple questions in aforementioned scientific disciplines in a sucessful manner,</li> <li>• justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject.</li> </ul> <p><b>Personal Competence</b></p>

<i>Social Competence</i>	<p><b>Personal Competences (Social Skills)</b></p> <p>Students will be able</p> <ul style="list-style-type: none"> <li>• to learn to collaborate in different manner,</li> <li>• to present and analyze problems in the abovementioned fields in a partner or group situation in a manner appropriate to the addressees,</li> <li>• 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),</li> <li>• to explain nontechnical items to auditorium with technical background knowledge.</li> </ul>
<i>Autonomy</i>	<p><b>Personal Competences (Self-reliance)</b></p> <p>Students are able in selected areas</p> <ul style="list-style-type: none"> <li>• to reflect on their own profession and professionalism in the context of real-life fields of application</li> <li>• to organize themselves and their own learning processes</li> <li>• to reflect and decide questions in front of a broad education background</li> <li>• to communicate a nontechnical item in a competent way in written form or verbally</li> <li>• to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen)</li> </ul>
<b>Workload in Hours</b>	Depends on choice of courses
<b>Credit points</b>	6

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

Module M0642: Physics for Engineers				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
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
<b>Module Responsible</b>	Prof. Manfred Eich			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Calculus and linear algebra on high school level</li> <li>• Physics on high school level</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	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.			
<i>Skills</i>	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.			
<b>Personal Competence</b>				
<i>Social Competence</i>	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.			
<i>Autonomy</i>	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.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	None	Subject theoretical practical work	and 4-seitige handschriftliche Versuchsvorbereitung, Ausarbeitung unter Anleitung und Testat
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 Minutes			
<b>Assignment for the Following Curricula</b>	Digital Mechanical Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory			

Course L0367: Physics for Engineers	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Manfred Eich
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction</li> <li>• Kinematics and dynamics</li> <li>• Work, Energy, momentum</li> <li>• Rotatory Motion, moments of inertia</li> <li>• Gravitation</li> <li>• Special Theory of Relativity</li> <li>• Oscillations</li> <li>• Waves</li> <li>• Geometrical optics</li> <li>• Wave optics</li> <li>• Matter waves</li> <li>• Fundamentals of quantum mechanics</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Giancoli, Physics for Scientists &amp; Engineers Vol. 1, 2, Pearson</li> <li>• Halliday/Resnik/Walker, <i>Fundamentals of physics</i>, Wiley</li> <li>• K. Cummings, P. Laws, E. Redish, and P. Cooney ("CLRC"), <i>Understanding Physics</i>, Wiley</li> <li>• Gerthsen/Vogel, <i>Physik</i>, Springer Verlag</li> <li>• Hering/Martin/Stohrer, <i>Physik für Ingenieure</i>, VDI-Verlag</li> </ul>



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

<b>Course L0948: Physics-Lab for ET</b>	
<b>Typ</b>	Practical Course
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Wolfgang Hansen
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>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".</p> <p>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.</p>
<b>Literature</b>	<p>Zu den Versuchen gibt es individuelle Versuchsanleitungen, die vor der Versuchsdurchführung ausgegeben werden.</p> <p>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.</p>

Module M0743: Electrical Engineering I: Direct Current Networks and Electromagnetic Fields			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>
Electrical Engineering I: Direct Current Networks and Electromagnetic Fields (L0675)		Lecture	3
Electrical Engineering I: Direct Current Networks and Electromagnetic Fields (L0676)		Recitation Section (small)	2
<b>CP</b>			
			5
			1
<b>Module Responsible</b>	Prof. Matthias Kuhl		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i> <i>Skills</i>			
<b>Personal Competence</b> <i>Social Competence</i> <i>Autonomy</i>			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	100 Minutes		
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	5
<b>Workload in Hours</b>	Independent Study Time 108, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Matthias Kuhl
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	
<b>Literature</b>	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	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 2, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Matthias Kuhl
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	
<b>Literature</b>	1. Übungsaufgaben zur Elektrotechnik 1, TUHH, 2013 2. Ch. Kautz: Tutorien zur Elektrotechnik, Pearson Studium, 2010

<b>Module M0829: Foundations of Management</b>			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Management Tutorial (L0882)	Recitation Section (small)	2	3
Introduction to Management (L0880)	Lecture	3	3
<b>Module Responsible</b>	Prof. Christoph Ihl		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basic Knowledge of Mathematics and Business		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	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		
<i>Knowledge</i>	<ul style="list-style-type: none"> <li>• explain the differences between Economics and Management and the sub-disciplines in Management and to name important definitions from the field of Management</li> <li>• explain the most important aspects of and goals in Management and name the most important aspects of entrepreneurial projects</li> <li>• describe and explain basic business functions as production, procurement and sourcing, supply chain management, organization and human resource management, information management, innovation management and marketing</li> <li>• 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</li> <li>• state basics from accounting and costing and selected controlling methods.</li> </ul>		
<i>Skills</i>	<p>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</p> <ul style="list-style-type: none"> <li>• analyse Management goals and structure them appropriately</li> <li>• analyse organisational and staff structures of companies</li> <li>• apply methods for decision making under multiple objectives, under uncertainty and under risk</li> <li>• analyse production and procurement systems and Business information systems</li> <li>• analyse and apply basic methods of marketing</li> <li>• select and apply basic methods from mathematical finance to predefined problems</li> <li>• apply basic methods from accounting, costing and controlling to predefined problems</li> </ul>		
<b>Personal Competence</b>	Students are able to		
<i>Social Competence</i>	<ul style="list-style-type: none"> <li>• work successfully in a team of students</li> <li>• to apply their knowledge from the lecture to an entrepreneurship project and write a coherent report on the project</li> <li>• to communicate appropriately and</li> <li>• to cooperate respectfully with their fellow students.</li> </ul>		
<i>Autonomy</i>	<p>Students are able to</p> <ul style="list-style-type: none"> <li>• work in a team and to organize the team themselves</li> <li>• to write a report on their project.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Subject theoretical and practical work		
<b>Examination duration and scale</b>	several written exams during the semester		
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Christoph Ihl, Katharina Roedelius
<b>Language</b>	DE
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	<p>In the management tutorial, the contents of the lecture will be deepened by practical examples and the application of the discussed tools.</p> <p>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 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 business knowledge from the lecture should come to practical use. The group projects are guided by a mentor.</p>
<b>Literature</b>	Relevante Literatur aus der korrespondierenden Vorlesung.

Course L0880: Introduction to Management	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Christoph Ihl, Prof. Christian Lühje, Prof. Christian Ringle, Prof. Cornelius Herstatt, Prof. Kathrin Fischer, Prof. Matthias Meyer, Prof. Thomas Wrona, Prof. Thorsten Blecker, Prof. Wolfgang Kersten
<b>Language</b>	DE
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction to Business and Management, Business versus Economics, relevant areas in Business and Management</li> <li>• Important definitions from Management,</li> <li>• Developing Objectives for Business, and their relation to important Business functions</li> <li>• Business Functions: Functions of the Value Chain, e.g. Production and Procurement, Supply Chain Management, Innovation Management, Marketing and Sales</li> <li>• Cross-sectional Functions, e.g. Organisation, Human Resource Management, Supply Chain Management, Information Management</li> <li>• Definitions as information, information systems, aspects of data security and strategic information systems</li> <li>• Definition and Relevance of innovations, e.g. innovation opportunities, risks etc.</li> <li>• Relevance of marketing, B2B vs. B2C-Marketing</li> <li>• different techniques from the field of marketing (e.g. scenario technique), pricing strategies</li> <li>• important organizational structures</li> <li>• basics of human resource management</li> <li>• Introduction to Business Planning and the steps of a planning process</li> <li>• Decision Analysis: Elements of decision problems and methods for solving decision problems</li> <li>• Selected Planning Tasks, e.g. Investment and Financial Decisions</li> <li>• Introduction to Accounting: Accounting, Balance-Sheets, Costing</li> <li>• Relevance of Controlling and selected Controlling methods</li> <li>• Important aspects of Entrepreneurship projects</li> </ul>
<b>Literature</b>	<p>Bamberg, G., Coenenberg, A.: Betriebswirtschaftliche Entscheidungslehre, 14. Aufl., München 2008</p> <p>Eisenführ, F., Weber, M.: Rationales Entscheiden, 4. Aufl., Berlin et al. 2003</p> <p>Heinhold, M.: Buchführung in Fallbeispielen, 10. Aufl., Stuttgart 2006.</p> <p>Kruschwitz, L.: Finanzmathematik. 3. Auflage, München 2001.</p> <p>Pellens, B., Fülbier, R. U., Gassen, J., Sellhorn, T.: Internationale Rechnungslegung, 7. Aufl., Stuttgart 2008.</p> <p>Schweitzer, M.: Planung und Steuerung, in: Bea/Friedl/Schweitzer: Allgemeine Betriebswirtschaftslehre, Bd. 2: Führung, 9. Aufl., Stuttgart 2005.</p> <p>Weber, J., Schäffer, U. : Einführung in das Controlling, 12. Auflage, Stuttgart 2008.</p> <p>Weber, J./Weißenberger, B.: Einführung in das Rechnungswesen, 7. Auflage, Stuttgart 2006.</p>

Module M0850: Mathematics I				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Mathematics I (L2970)		Lecture	4	4
Mathematics I (L2971)		Recitation Section (large)	2	2
Mathematics I (L2972)		Recitation Section (small)	2	2
<b>Module Responsible</b>	Prof. Anusch Taraz			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	School mathematics			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<ul style="list-style-type: none"> <li>• Students can name the basic concepts in analysis and linear algebra. They are able to explain them using appropriate examples.</li> <li>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>• They know proof strategies and can reproduce them.</li> </ul> <ul style="list-style-type: none"> <li>• 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.</li> <li>• Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul> <ul style="list-style-type: none"> <li>• Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>• 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.</li> </ul> <ul style="list-style-type: none"> <li>• 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.</li> <li>• Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>			
<i>Knowledge</i>				
<i>Skills</i>				
<b>Personal Competence</b>				
<i>Social Competence</i>				
<i>Autonomy</i>				
<b>Workload in Hours</b>	Independent Study Time 128, Study Time in Lecture 112			
<b>Credit points</b>	8			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	10 %	Excercises	
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 min			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 64, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Anusch Taraz
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Mathematical Foundations:</p> <p>sets, statements, induction, mappings, trigonometry</p> <p>Analysis: Foundations of differential calculus in one variable</p> <ul style="list-style-type: none"> <li>• natural and real numbers</li> <li>• convergence of sequences and series</li> <li>• continuous and differentiable functions</li> <li>• mean value theorems</li> <li>• Taylor series</li> <li>• calculus</li> <li>• error analysis</li> <li>• fixpoint iteration</li> </ul> <p>Linear Algebra: Foundations of linear algebra in <math>\mathbb{R}^n</math></p> <ul style="list-style-type: none"> <li>• vectors: rules, linear combinations, inner and cross product, lines and planes</li> <li>• systems of linear equations: Gauß elimination, linear mappings, matrix multiplication, inverse matrices, determinants</li> <li>• orthogonal projection in <math>\mathbb{R}^n</math>, Gram-Schmidt-Orthonormalization</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• T. Arens u.a. : Mathematik, Springer Spektrum, Heidelberg 2015</li> <li>• W. Mackens, H. Voß: Mathematik I für Studierende der Ingenieurwissenschaften, HECO-Verlag, Alsdorf 1994</li> <li>• W. Mackens, H. Voß: Aufgaben und Lösungen zur Mathematik I für Studierende der Ingenieurwissenschaften, HECO-Verlag, Alsdorf 1994</li> <li>• G. Strang: Lineare Algebra, Springer-Verlag, 2003</li> <li>• G. und S. Teschl: Mathematik für Informatiker, Band 1, Springer-Verlag, 2013</li> </ul>

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

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

Module M1692: Computer Science for Engineers - Introduction and Overview				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Computer Science for Engineers - Introduction and Overview (L2685)		Lecture	3	3
Computer Science for Engineers - Introduction and Overview (L2686)		Recitation Section (small)	2	3
<b>Module Responsible</b>	Prof. Görschwin Fey			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>				
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i> <i>Skills</i>				
<b>Personal Competence</b> <i>Social Competence</i> <i>Autonomy</i>				
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	No	10 %	Attestation	Testate finden semesterbegleitend statt.
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 min			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Görschwin Fey
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Informatik                             <ul style="list-style-type: none"> <li>◦ Helmut Herold, Bruno Lurz, Jürgen Wohlrab, Matthias Hopf: Grundlagen der Informatik, 3. Auflage, 816 Seiten, Pearson Studium, 2017.</li> </ul> </li> <li>• C++                             <ul style="list-style-type: none"> <li>◦ Bjarne Stroustrup, Einführung in die Programmierung mit C++, 479 Seiten, Pearson Studium, 2010. --&gt; in der englischen Version bereits eine neuere Auflage!</li> <li>◦ Jürgen Wolf : Grundkurs C++: C++-Programmierung verständlich erklärt, Rheinwerk Computing, 3. Auflage, 2016.</li> </ul> </li> </ul>

Course L2686: Computer Science for Engineers - Introduction and Overview	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Görschwin Fey
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0547: Electrical Engineering II: Alternating Current Networks and Basic Devices				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
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
<b>Module Responsible</b>	Prof. Christian Becker			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Electrical Engineering I Mathematics I Direct current networks, complex numbers			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students are able to work together on subject related tasks in small groups. They are able to present their results effectively.</p> <p><i>Autonomy</i> 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).</p>			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	No	10 %	Midterm	
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 - 150 minutes			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	5
<b>Workload in Hours</b>	Independent Study Time 108, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Christian Becker
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- General time-dependency of electrical networks</li> <li>- Representation and properties of harmonic signals</li> <li>- RLC-elements at alternating currents/voltages</li> <li>- Complex notation for the representation of RLC-elements</li> <li>- Power in electrical networks at alternating currents, compensation of reactive power</li> <li>- Frequency response locus (Nyquist plot) and Bode-diagrams</li> <li>- Measurement instrumentation for assessing alternating currents</li> <li>- Oscillating circuits, filters, electrical transmission lines</li> <li>- Transformers, three-phase current, energy converters</li> <li>- Simple non-linear and active electrical devices</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- M. Albach, "Elektrotechnik", Pearson Studium (2011)</li> <li>- T. Harriehausen, D. Schwarzenau, "Moeller Grundlagen der Elektrotechnik", Springer (2013)</li> <li>- R. Kories, H. Schmidt-Walter, "Taschenbuch der Elektrotechnik", Harri Deutsch (2010)</li> <li>- C. Kautz, "Tutorien zur Elektrotechnik", Pearson (2009)</li> <li>- A. Hambley, "Electrical Engineering: Principles and Applications", Pearson (2013)</li> <li>- R. Dorf, "The Electrical Engineering Handbook", CRC (2006)</li> </ul>

<b>Course L0179: Electrical Engineering II: Alternating Current Networks and Basic Devices</b>	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 2, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Christian Becker
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- General time-dependency of electrical networks</li> <li>- Representation and properties of harmonic signals</li> <li>- RLC-elements at alternating currents/voltages</li> <li>- Complex notation for the representation of RLC-elements</li> <li>- Power in electrical networks at alternating currents, compensation of reactive power</li> <li>- Frequency response locus (Nyquist plot) and Bode-diagrams</li> <li>- Measurement instrumentation for assessing alternating currents</li> <li>- Oscillating circuits, filters, electrical transmission lines</li> <li>- Transformers, three-phase current, energy converters</li> <li>- Simple non-linear and active electrical devices</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- M. Albach, "Elektrotechnik", Pearson Studium (2011)</li> <li>- T. Harriehausen, D. Schwarzenau, "Moeller Grundlagen der Elektrotechnik", Springer (2013)</li> <li>- R. Kories, H. Schmidt-Walter, "Taschenbuch der Elektrotechnik", Harri Deutsch (2010)</li> <li>- C. Kautz, "Tutorien zur Elektrotechnik", Pearson (2009)</li> <li>- A. Hambley, "Electrical Engineering: Principles and Applications", Pearson (2013)</li> <li>- R. Dorf, "The Electrical Engineering Handbook", CRC (2006)</li> </ul>

Module M0748: Materials in Electrical Engineering			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
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
<b>Module Responsible</b>	Prof. Manfred Eich		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Highschool level physics and mathematics		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students can jointly solve subject related problems in groups. They can present their results effectively within the framework of the problem solving course.</p> <p><i>Autonomy</i> 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.</p>		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	60 minutes		
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Dr. Helge Fielitz
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Agenda:</p> <ul style="list-style-type: none"> <li>- Natural sources of electricity</li> <li>- Oscilloscope</li> <li>- Characterizing signals</li> <li>- 2 terminal circuit elements</li> <li>- 2-ports</li> <li>- Power</li> <li>- Matching</li> <li>- Inductive coupling</li> <li>- Resonance</li> <li>- Radio frequencies</li> <li>- Transistor circuits</li> <li>- Electrical measurement</li> <li>- Materials for the EE</li> <li>- Electrical fun</li> </ul>
<b>Literature</b>	Tietze, Schenk: "Halbleiterschaltungstechnik", Springer

<b>Course L0685: Materials in Electrical Engineering</b>	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Manfred Eich
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>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</p>
<b>Literature</b>	<ol style="list-style-type: none"> <li>1. Anikeeva, Beach, Holten-Andersen, Fink, Electronic, Optical and Magnetic Properties of Materials, Massachusetts Institute of Technology (MIT), 2013</li> <li>2. Hagelstein et al., Introductory Applied Quantum and Statistical Mechanics, Wiley 2004</li> <li>3. Griffiths, Introduction to Quantum Mechanics, Prentice Hall, 1994</li> <li>4. Shankar, Principles of Quantum Mechanics, 2nd ed., Plenum Press, 1994</li> <li>5. Fick, Einführung in die Grundlagen der Quantentheorie, Akad. Verlagsges., 1979</li> <li>6. Kittel, Introduction to Solid State Physics, 8th ed., Wiley, 2004</li> <li>7. Ashcroft, Mermin, Solid State Physics, Harcourt, 1976</li> <li>8. Pierret, Semiconductor Fundamentals Vol. 1, Addison Wesley, 1988</li> <li>9. Sze, Physics of Semiconductor Devices, Wiley, 1981</li> <li>10. Saleh, Teich, Fundamentals of Photonics, 2nd ed., 2007</li> <li>11. Joannopoulos, Johnson, Winn Meade, Photonic Crystals, 2nd ed., Princeton University Press, 2008</li> <li>12. Handley, Modern Magnetic Materials, Wiley, 2000</li> <li>13. Wikipedia, Wikimedia</li> </ol>

<b>Course L0687: Materials in Electrical Engineering (Problem Solving Course)</b>	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Manfred Eich
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Atom structure and periodic system</li> <li>• Atom binding and crystal structure</li> <li>• Structure and properties of alloys: diffusion, phase diagrams, phase separation and grain boundaries</li> <li>• Material properties: Mechanical, thermal, electrical, dielectric properties</li> <li>• Metals</li> <li>• Semiconductors</li> <li>• Ceramics and glasses</li> <li>• Polymers</li> <li>• Magnetic materials</li> <li>• Electrochemistry Oxidation numbers, electrolysis, batteries, fuel cells</li> </ul>
<b>Literature</b>	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	
<b>Module Responsible</b>	Prof. Anusch Taraz			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Mathematics I			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<ul style="list-style-type: none"> <li>• Students can name further concepts in analysis and linear algebra. They are able to explain them using appropriate examples.</li> <li>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>• They know proof strategies and can reproduce them.</li> </ul>			
<i>Knowledge</i>				
<i>Skills</i>				
<b>Personal Competence</b>				
<i>Social Competence</i>	<ul style="list-style-type: none"> <li>• 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.</li> <li>• Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul>			
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>• Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>• 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.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 128, Study Time in Lecture 112			
<b>Credit points</b>	8			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	10 %	Excercises	
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 min			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 64, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Anusch Taraz
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	

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

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



Module M1693: Computer Science for Engineers - Programming Concepts, Data Handling & Communication				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
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
<b>Module Responsible</b>	Prof. Sibylle Fröschle			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>				
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i> <i>Skills</i>				
<b>Personal Competence</b> <i>Social Competence</i> <i>Autonomy</i>				
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	No	10 %	Attestation	Testate finden semesterbegleitend statt.
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 min			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Sibylle Fröschle
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	John V. Guttag: Introduction to Computation and Programming Using Python. With Application to Understanding Data. 2nd Edition. The MIT Press, 2016.

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

Module M0783: Measurements: Methods and Data Processing				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
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
<b>Module Responsible</b>	Prof. Alexander Schlaefer			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	principles of mathematics principles of electrical engineering			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	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.			
<i>Skills</i>	The students are able to evaluate problems of metrology and to apply methods for describing and processing of measurements.			
<b>Personal Competence</b>				
<i>Social Competence</i>	The students solve problems in small groups.			
<i>Autonomy</i>	The students can reflect their knowledge and discuss and evaluate their results.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	10 %	Excercises	
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 min			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Practical Course
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	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
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	lab experiments: digital circuits, semiconductors, micro controllers, analog circuits, AC power, electrical machines
<b>Literature</b>	Wird in der Lehrveranstaltung festgelegt

Course L0779: Measurements: Methods and Data Processing	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Alexander Schlaefer
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	introduction, systems and errors in metrology, probability theory, measuring stochastic signals, describing measurements, acquisition of analog signals, applied metrology
<b>Literature</b>	Puente León, Kiencke: Messtechnik, Springer 2012 Lerch: Elektrische Messtechnik, Springer 2012  Weitere Literatur wird in der Veranstaltung bekanntgegeben.

<b>Course L0780: Measurements: Methods and Data Processing</b>	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Alexander Schlaefer
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Alexander Kölpin		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Electrical Engineering I and II, Mathematics I and II		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	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.		
<i>Skills</i>	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.		
<b>Personal Competence</b>			
<i>Social Competence</i>	Students work on exercise tasks in small guided groups. They are encouraged to present and discuss their results within the group.		
<i>Autonomy</i>	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.		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	150 min		
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Alexander Kölpin, Dr. Fabian Lurz
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- Circuit theorems</li> <li>- N-port circuits</li> <li>- Periodic excitation of linear circuits</li> <li>- Transient analysis in time domain</li> <li>- Transient analysis in frequency domain; Laplace Transform</li> <li>- Frequency behaviour of passive one-ports</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- M. Albach, "Grundlagen der Elektrotechnik 1", Pearson Studium (2011)</li> <li>- M. Albach, "Grundlagen der Elektrotechnik 2", Pearson Studium (2011)</li> <li>- L. P. Schmidt, G. Schaller, S. Martius, "Grundlagen der Elektrotechnik 3", Pearson Studium (2011)</li> <li>- T. Harriehausen, D. Schwarzenau, "Moeller Grundlagen der Elektrotechnik", Springer (2013)</li> <li>- A. Hambley, "Electrical Engineering: Principles and Applications", Pearson (2008)</li> <li>- R. C. Dorf, J. A. Svoboda, "Introduction to electrical circuits", Wiley (2006)</li> <li>- L. Moura, I. Darwazeh, "Introduction to Linear Circuit Analysis and Modeling", Amsterdam Newnes (2005)</li> </ul>

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

Module M0730: Computer Engineering				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Computer Engineering (L0321)		Lecture	3	4
Computer Engineering (L0324)		Recitation Section (small)	1	2
<b>Module Responsible</b>	Prof. Heiko Falk			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge in electrical engineering			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i></p> <p>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:</p> <ul style="list-style-type: none"> <li>• Introduction</li> <li>• Combinational logic: Gates, Boolean algebra, Boolean functions, hardware synthesis, combinational networks</li> <li>• Sequential logic: Flip-flops, automata, systematic hardware design</li> <li>• Technological foundations</li> <li>• Computer arithmetic: Integer addition, subtraction, multiplication and division</li> <li>• Basics of computer architecture: Programming models, MIPS single-cycle architecture, pipelining</li> <li>• Memories: Memory hierarchies, SRAM, DRAM, caches</li> <li>• Input/output: I/O from the perspective of the CPU, principles of passing data, point-to-point connections, busses</li> </ul> <p><i>Skills</i></p> <p>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.</p> <p>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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i></p> <p>Students are able to solve similar problems alone or in a group and to present the results accordingly.</p> <p><i>Autonomy</i></p> <p>Students are able to acquire new knowledge from specific literature and to associate this knowledge with other classes.</p>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	10 %	Excercises	
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 minutes, contents of course and labs			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Heiko Falk
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction</li> <li>• Combinational Logic</li> <li>• Sequential Logic</li> <li>• Technological Foundations</li> <li>• Representations of Numbers, Computer Arithmetics</li> <li>• Foundations of Computer Architecture</li> <li>• Memories</li> <li>• Input/Output</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• A. Clements. The Principles of Computer Hardware. 3. Auflage, Oxford University Press, 2000.</li> <li>• A. Tanenbaum, J. Goodman. Computerarchitektur. Pearson, 2001.</li> <li>• D. Patterson, J. Hennessy. Rechnerorganisation und -entwurf. Elsevier, 2005.</li> </ul>

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



Module M0853: Mathematics III				
<b>Courses</b>				
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	
<b>Module Responsible</b>	Prof. Marko Lindner			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Mathematics I + II			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<ul style="list-style-type: none"> <li>• Students can name the basic concepts in the area of analysis and differential equations. They are able to explain them using appropriate examples.</li> <li>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>• They know proof strategies and can reproduce them.</li> </ul>			
<i>Knowledge</i>				
<i>Skills</i>				
<b>Personal Competence</b>				
<i>Social Competence</i>	<ul style="list-style-type: none"> <li>• 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.</li> <li>• Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul>			
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>• Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>• 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.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 128, Study Time in Lecture 112			
<b>Credit points</b>	8			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	60 min (Analysis III) + 60 min (Differential Equations 1)			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Main features of differential and integrational calculus of several variables</p> <ul style="list-style-type: none"> <li>• Differential calculus for several variables</li> <li>• Mean value theorems and Taylor's theorem</li> <li>• Maximum and minimum values</li> <li>• Implicit functions</li> <li>• Minimization under equality constraints</li> <li>• Newton's method for multiple variables</li> <li>• Fourier series</li> <li>• Double integrals over general regions</li> <li>• Line and surface integrals</li> <li>• Theorems of Gauß and Stokes</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• <a href="http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html">http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html</a></li> </ul>

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

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

Course L1031: Differential Equations 1 (Ordinary Differential Equations)	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Main features of the theory and numerical treatment of ordinary differential equations</p> <ul style="list-style-type: none"> <li>• Introduction and elementary methods</li> <li>• Existence and uniqueness of initial value problems</li> <li>• Linear differential equations</li> <li>• Stability and qualitative behaviour of the solution</li> <li>• Boundary value problems and basic concepts of calculus of variations</li> <li>• Eigenvalue problems</li> <li>• Numerical methods for the integration of initial and boundary value problems</li> <li>• Classification of partial differential equations</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• <a href="http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html">http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html</a></li> </ul>

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

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

Module M0567: Theoretical Electrical Engineering I: Time-Independent Fields			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Theoretical Electrical Engineering I: Time-Independent Fields (L0180)	Lecture	3	5
Theoretical Electrical Engineering I: Time-Independent Fields (L0181)	Recitation Section (small)	2	1
<b>Module Responsible</b>	Prof. Christian Schuster		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basic principles of electrical engineering and advanced mathematics		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	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.		
<i>Skills</i>	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.		
<b>Personal Competence</b>			
<i>Social Competence</i>	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).		
<i>Autonomy</i>	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).		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90-150 minutes		
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	5
<b>Workload in Hours</b>	Independent Study Time 108, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Christian Schuster
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- Maxwell's Equations in integral and differential notation</li> <li>- Boundary conditions</li> <li>- Laws of conservation for energy and charge</li> <li>- Classification of electromagnetic field properties</li> <li>- Integral characteristics of time-independent fields (R, L, C)</li> <li>- Generic approaches to solving Poisson's Equation</li> <li>- Electrostatic fields and specific methods of solving</li> <li>- Magnetostatic fields and specific methods of solving</li> <li>- Fields of electrical current density and specific methods of solving</li> <li>- Action of force within time-independent fields</li> <li>- Numerical methods for solving time-independent problems</li> </ul> <p>The practical application of numerical methods will be trained within specifically prepared lectures in an interactive manner using small MATLAB programs.</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- G. Lehner, "Elektromagnetische Feldtheorie: Für Ingenieure und Physiker", Springer (2010)</li> <li>- H. Henke, "Elektromagnetische Felder: Theorie und Anwendung", Springer (2011)</li> <li>- W. Nolting, "Grundkurs Theoretische Physik 3: Elektrodynamik", Springer (2011)</li> <li>- D. Griffiths, "Introduction to Electrodynamics", Pearson (2012)</li> <li>- J. Edminister, "Schaum's Outline of Electromagnetics", McGraw-Hill (2013)</li> <li>- Richard Feynman, "Feynman Lectures on Physics: Volume 2", Basic Books (2011)</li> </ul>

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

<b>Module M0610: Electrical Machines and Actuators</b>			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Electrical Machines and Actuators (L0293)	Lecture	3	4
Electrical Machines and Actuators (L0294)	Recitation Section (large)	2	2
<b>Module Responsible</b>	Prof. Thorsten Kern		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basics of mathematics, in particular complex numbers, integrals, differentials Basics of electrical engineering and mechanical engineering		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> Students can 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.</p> <p><i>Skills</i> 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 of electric machines. They can calculate 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.</p>		
<b>Personal Competence</b>	<p><i>Social Competence</i> none</p> <p><i>Autonomy</i> Students are able independently to calculate electric and magnetic fields for applications. They are able to analyse independently the operational performance of electric machines from the characteristic data and they can calculate thereof selected quantities and characteristic curves.</p>		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Subject theoretical and practical work		
<b>Examination duration and scale</b>	Design of four machines and actuators, review of design files		
<b>Assignment for the Following Curricula</b>	<p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory</p> <p>Digital Mechanical Engineering: Core Qualification: Compulsory</p> <p>Electrical Engineering: Core Qualification: Elective Compulsory</p> <p>Engineering Science: Specialisation Electrical Engineering: Elective Compulsory</p> <p>Engineering Science: Specialisation Electrical Engineering: Elective Compulsory</p> <p>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory</p> <p>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory</p> <p>Computer Science in Engineering: Specialisation II. Mathematics &amp; Engineering Science: Elective Compulsory</p> <p>Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory</p> <p>Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory</p> <p>Mechanical Engineering: Core Qualification: Elective Compulsory</p> <p>Mechatronics: Specialisation Naval Engineering: Compulsory</p> <p>Mechatronics: Core Qualification: Compulsory</p> <p>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory</p> <p>Mechatronics: Specialisation Electrical Systems: Elective Compulsory</p> <p>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory</p> <p>Engineering and Management - Major in Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory</p> <p>Engineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Elective Compulsory</p> <p>Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory</p> <p>Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory</p>		

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

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

Module M0672: Signals and Systems			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>
Signals and Systems (L0432)		Lecture	3
Signals and Systems (L0433)		Recitation Section (small)	2
<b>Module Responsible</b>	Prof. Gerhard Bauch		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	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.		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p>The students are familiar with the contents of lecture and tutorials. They can explain and apply them to new problems.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> The students can jointly solve specific problems.</p> <p><i>Autonomy</i> 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.</p>		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90 min		
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Gerhard Bauch
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction to signal and system theory</li> <li>• Signals                             <ul style="list-style-type: none"> <li>◦ Classification of signals                                     <ul style="list-style-type: none"> <li>▪ Continuous-time and discrete-time signals</li> <li>▪ Analog and digital signals</li> <li>▪ Deterministic and random signals</li> </ul> </li> <li>◦ Description of LTI systems by differential equations or difference equations, respectively</li> <li>◦ Basic properties of signals and operations on signals</li> <li>◦ Elementary signals</li> <li>◦ Distributions (Generalized Functions)</li> <li>◦ Power and energy of signals</li> <li>◦ Correlation functions of deterministic signals                                     <ul style="list-style-type: none"> <li>▪ Autocorrelation function</li> <li>▪ Crosscorrelation function</li> <li>▪ Orthogonal signals</li> <li>▪ Applications of correlation</li> </ul> </li> </ul> </li> <li>• Linear time-invariant (LTI) systems</li> </ul>



	<ul style="list-style-type: none"> <li>◦ Linearity</li> <li>◦ Time-invariance</li> <li>◦ Description of LTI systems by impulse response and frequency response</li> <li>◦ Convolution</li> <li>◦ Convolution and correlation</li> <li>◦ Properties of LTI-systems</li> <li>◦ Causal systems</li> <li>◦ Stable systems</li> <li>◦ Memoryless systems</li> <li>• Fourier Series and Fourier Transform             <ul style="list-style-type: none"> <li>◦ Fourier transform of continuous-time signals, discrete-time signals, periodic signals, non-periodic signals</li> <li>◦ Properties of the Fourier transform</li> <li>◦ Fourier transform of some basic signals</li> <li>◦ Parseval's theorem</li> </ul> </li> <li>• Analysis of LTI-systems and signals in the frequency domain             <ul style="list-style-type: none"> <li>◦ Frequency response, magnitude response and phase response</li> <li>◦ Transmission factor, attenuation, gain</li> <li>◦ Frequency-flat and frequency-selective LTI-systems</li> <li>◦ Bandwidth definitions</li> <li>◦ Basic types of systems (filters), lowpass, highpass, bandpass, bandstop systems</li> <li>◦ Phase delay and group delay</li> <li>◦ Linear-phase systems</li> <li>◦ Distortion-free systems</li> <li>◦ Spectrum analysis with limited observation window: Leakage effect</li> </ul> </li> <li>• Laplace Transform             <ul style="list-style-type: none"> <li>◦ Relation of Fourier transform and Laplace transform</li> <li>◦ Properties of the Laplace transform</li> <li>◦ Laplace transform of some basic signals</li> </ul> </li> <li>• Analysis of LTI-systems in the s-domain             <ul style="list-style-type: none"> <li>◦ Transfer function of LTI-systems</li> <li>◦ Relation of Laplace transform, magnitude response and phase response</li> <li>◦ Analysis of LTI-systems using pole-zero plots</li> <li>◦ Allpass filters</li> <li>◦ Minimum-phase, maximum-phase and mixed phase filters</li> <li>◦ Stable systems</li> </ul> </li> <li>• Sampling             <ul style="list-style-type: none"> <li>◦ Sampling theorem</li> <li>◦ Reconstruction of continuous-time signals in frequency domain and time domain</li> <li>◦ Oversampling</li> <li>◦ Aliasing</li> <li>◦ Sampling with pulses of finite duration, sample and hold</li> <li>◦ Decimation and interpolation</li> </ul> </li> <li>• Discrete-Time Fourier Transform (DTFT)             <ul style="list-style-type: none"> <li>◦ Relation of Fourier transform and DTFT</li> <li>◦ Properties of the DTFT</li> </ul> </li> <li>• Discrete Fourier Transform (DFT)             <ul style="list-style-type: none"> <li>◦ Relation of DTFT and DFT</li> <li>◦ Cyclic properties of the DFT</li> <li>◦ DFT matrix</li> <li>◦ Zero padding</li> <li>◦ Cyclic convolution</li> <li>◦ Fast Fourier Transform (FFT)</li> <li>◦ Application of the DFT: Orthogonal Frequency Division Multiplex (OFDM)</li> </ul> </li> <li>• Z-Transform             <ul style="list-style-type: none"> <li>◦ Relation of Laplace transform, DTFT, and z-transform</li> <li>◦ Properties of the z-transform</li> <li>◦ Z-transform of some basic discrete-time signals</li> </ul> </li> <li>• Discrete-time systems, digital filters             <ul style="list-style-type: none"> <li>◦ FIR and IIR filters</li> <li>◦ Z-transform of digital filters</li> <li>◦ Analysis of discrete-time systems using pole-zero plots in the z-domain</li> <li>◦ Stability</li> <li>◦ Allpass filters</li> <li>◦ Minimum-phase, maximum-phase and mixed-phase filters</li> <li>◦ Linear phase filters</li> </ul> </li> </ul>
<p><b>Literature</b></p>	<ul style="list-style-type: none"> <li>• T. Frey , M. Bossert , Signal- und Systemtheorie, B.G. Teubner Verlag 2004</li> <li>• K. Kammeyer, K. Kroschel, Digitale Signalverarbeitung, Teubner Verlag.</li> <li>• B. Girod ,R. Rabensteiner , A. Stenger , Einführung in die Systemtheorie, B.G. Teubner, Stuttgart, 1997</li> <li>• J.R. Ohm, H.D. Lüke , Signalübertragung, Springer-Verlag 8. Auflage, 2002</li> <li>• S. Haykin, B. van Veen: Signals and systems. Wiley.</li> <li>• Oppenheim, A.S. Willsky: Signals and Systems. Pearson.</li> </ul>

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

<b>Course L0433: Signals and Systems</b>	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Gerhard Bauch
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Christian Becker		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Electrical Engineering I, Electrical Engineering II		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> 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.</p> <p><i>Autonomy</i> Students are capable of independently solving electrical engineering problems using provided literature. They are able to fill gaps in as well as extend 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.</p>		
<b>Workload in Hours</b>	Independent Study Time 68, Study Time in Lecture 112		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Subject theoretical and practical work		
<b>Examination duration and scale</b>	based on task + presentation		
<b>Assignment for the Following Curricula</b>	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		

<b>Course L0640: Electrical Engineering Project Laboratory</b>	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	8
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 68, Study Time in Lecture 112
<b>Lecturer</b>	Prof. Christian Becker, Dozenten des SD E
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	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.
<b>Literature</b>	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			
<b>Courses</b>			
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
<b>Module Responsible</b>	Prof. Marko Lindner		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Mathematics I - III		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<ul style="list-style-type: none"> <li>• Students can name the basic concepts in Mathematics IV. They are able to explain them using appropriate examples.</li> <li>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>• They know proof strategies and can reproduce them.</li> </ul> <ul style="list-style-type: none"> <li>• 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.</li> <li>• Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul> <ul style="list-style-type: none"> <li>• Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>• 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.</li> </ul> <ul style="list-style-type: none"> <li>• 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.</li> <li>• Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>		
<i>Knowledge</i>			
<i>Skills</i>			
<i>Social Competence</i>			
<b>Personal Competence</b>			
<i>Social Competence</i>			
<i>Autonomy</i>			
<b>Workload in Hours</b>	Independent Study Time 68, Study Time in Lecture 112		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	60 min (Complex Functions) + 60 min (Differential Equations 2)		
<b>Assignment for the Following Curricula</b>	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)	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 2, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Main features of the theory and numerical treatment of partial differential equations</p> <ul style="list-style-type: none"> <li>• Examples of partial differential equations</li> <li>• First order quasilinear differential equations</li> <li>• Normal forms of second order differential equations</li> <li>• Harmonic functions and maximum principle</li> <li>• Maximum principle for the heat equation</li> <li>• Wave equation</li> <li>• Liouville's formula</li> <li>• Special functions</li> <li>• Difference methods</li> <li>• Finite elements</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• <a href="http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html">http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html</a></li> </ul>

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

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

Course L1038: Complex Functions	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 2, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Main features of complex analysis</p> <ul style="list-style-type: none"> <li>• Functions of one complex variable</li> <li>• Complex differentiation</li> <li>• Conformal mappings</li> <li>• Complex integration</li> <li>• Cauchy's integral theorem</li> <li>• Cauchy's integral formula</li> <li>• Taylor and Laurent series expansion</li> <li>• Singularities and residuals</li> <li>• Integral transformations: Fourier and Laplace transformation</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• <a href="http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html">http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html</a></li> </ul>

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

Course L1042: Complex Functions	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Christian Schuster		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basic principles of physics and electrical engineering		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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:</p> <ul style="list-style-type: none"> <li>- Fundamental properties and phenomena of electrical circuits</li> <li>- Steady-state sinusoidal analysis of electrical circuits</li> <li>- Fundamental properties and phenomena of electromagnetic fields and waves</li> <li>- Steady-state sinusoidal description of electromagnetic fields and waves</li> <li>- Useful microwave network parameters</li> <li>- Transmission lines and basic results from transmission line theory</li> <li>- Plane wave propagation, superposition, reflection and refraction</li> <li>- General theory of waveguides</li> <li>- Most important types of waveguides and their properties</li> <li>- Radiation and basic antenna parameters</li> <li>- Most important types of antennas and their properties</li> <li>- Numerical techniques and CAD tools for waveguide and antenna design</li> <li>- Fundamentals of Electromagnetic Compatibility</li> <li>- Coupling mechanisms and countermeasures</li> <li>- Shielding, grounding, filtering</li> <li>- Standards and regulations</li> <li>- EMC measurement techniques</li> </ul> <p><i>Skills</i> 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 Compatibility to the development of electrical components and systems.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> 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).</p> <p><i>Autonomy</i> 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.</p>		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	45 min		
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Christian Schuster
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>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.</p> <p>Topics:</p> <ul style="list-style-type: none"> <li>- Fundamental properties and phenomena of electrical circuits</li> <li>- Steady-state sinusoidal analysis of electrical circuits</li> <li>- Fundamental properties and phenomena of electromagnetic fields and waves</li> <li>- Steady-state sinusoidal description of electromagnetic fields and waves</li> <li>- Useful microwave network parameters</li> <li>- Transmission lines and basic results from transmission line theory</li> <li>- Plane wave propagation, superposition, reflection and refraction</li> <li>- General theory of waveguides</li> <li>- Most important types of waveguides and their properties</li> <li>- Radiation and basic antenna parameters</li> <li>- Most important types of antennas and their properties</li> <li>- Numerical techniques and CAD tools for waveguide and antenna design</li> <li>- Fundamentals of Electromagnetic Compatibility</li> <li>- Coupling mechanisms and countermeasures</li> <li>- Shielding, grounding, filtering</li> <li>- Standards and regulations</li> <li>- EMC measurement techniques</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- Zinke, Brunswig, "Hochfrequenztechnik 1", Springer (1999)</li> <li>- J. Detlefsen, U. Siart, "Grundlagen der Hochfrequenztechnik", Oldenbourg (2012)</li> <li>- D. M. Pozar, "Microwave Engineering", Wiley (2011)</li> <li>- Y. Huang, K. Boyle, "Antenna: From Theory to Practice", Wiley (2008)</li> <li>- H. Ott, "Electromagnetic Compatibility Engineering", Wiley (2009)</li> <li>- A. Schwab, W. Kürner, "Elektromagnetische Verträglichkeit", Springer (2007)</li> </ul>

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

Module M1962: Basics space electronics and primary mission			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>
Basics space electronics and primary mission (L3204)		Project-/problem-based Learning	4
<b>Module Responsible</b>	Prof. Ulf Kulau		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Electrical engineering / Fundamentals of electrical engineering</li> <li>• Computer science / Computer science for engineers</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	<ul style="list-style-type: none"> <li>• Fundamentals of space electronics,</li> <li>• Subcomponents of satellite systems</li> <li>• Fragmentation and planning of primary missions</li> <li>• Active participation in CubeSat mission to apply learned skills</li> <li>• Soft skills in project management, project planning and project communication</li> </ul>		
<i>Skills</i>	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.		
<b>Personal Competence</b>			
<i>Social Competence</i>	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.		
<i>Autonomy</i>	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.		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	Report on achieved results		
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Ulf Kulau
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	
<b>Literature</b>	

Module M1235: Electrical Power Systems I: Introduction to Electrical Power Systems			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>
Electrical Power Systems I: Introduction to Electrical Power Systems (L1670)		Lecture	3
Electrical Power Systems I: Introduction to Electrical Power Systems (L1671)		Recitation Section (small)	2
<b>Module Responsible</b>	Prof. Christian Becker		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Fundamentals of Electrical Engineering		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	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.		
<i>Skills</i>	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.		
<b>Personal Competence</b>			
<i>Social Competence</i>	The students can participate in specialized and interdisciplinary discussions, advance ideas and represent their own work results in front of others.		
<i>Autonomy</i>	Students can independently tap knowledge of the emphasis of the lectures.		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90 - 150 minutes		
<b>Assignment for the Following Curricula</b>	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 General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: 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 Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory		

Course L1670: Electrical Power Systems I: Introduction to Electrical Power Systems	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Christian Becker
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• fundamentals and current development trends in electric power engineering</li> <li>• tasks and history of electric power systems</li> <li>• symmetric three-phase systems</li> <li>• fundamentals and modelling of electric power systems                             <ul style="list-style-type: none"> <li>◦ lines</li> <li>◦ transformers</li> <li>◦ synchronous machines</li> <li>◦ induction machines</li> <li>◦ loads and compensation</li> <li>◦ grid structures and substations</li> </ul> </li> <li>• fundamentals of energy conversion                             <ul style="list-style-type: none"> <li>◦ electro-mechanical energy conversion</li> <li>◦ thermodynamics</li> <li>◦ power station technology</li> <li>◦ renewable energy conversion systems</li> </ul> </li> <li>• steady-state network calculation                             <ul style="list-style-type: none"> <li>◦ network modelling</li> <li>◦ load flow calculation</li> <li>◦ (n-1)-criterion</li> </ul> </li> <li>• symmetric failure calculations, short-circuit power</li> <li>• control in networks and power stations</li> <li>• grid protection</li> <li>• grid planning</li> </ul>
<b>Literature</b>	K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Springer Vieweg, 9. Auflage, 2013  A. J. Schwab: "Elektroenergiesysteme", Springer, 7. Auflage, 2022  R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008

Course L1671: Electrical Power Systems I: Introduction to Electrical Power Systems	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Christian Becker
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• fundamentals and current development trends in electric power engineering</li> <li>• tasks and history of electric power systems</li> <li>• symmetric three-phase systems</li> <li>• fundamentals and modelling of electric power systems                             <ul style="list-style-type: none"> <li>◦ lines</li> <li>◦ transformers</li> <li>◦ synchronous machines</li> <li>◦ induction machines</li> <li>◦ loads and compensation</li> <li>◦ grid structures and substations</li> </ul> </li> <li>• fundamentals of energy conversion                             <ul style="list-style-type: none"> <li>◦ electro-mechanical energy conversion</li> <li>◦ thermodynamics</li> <li>◦ power station technology</li> <li>◦ renewable energy conversion systems</li> </ul> </li> <li>• steady-state network calculation                             <ul style="list-style-type: none"> <li>◦ network modelling</li> <li>◦ load flow calculation</li> <li>◦ (n-1)-criterion</li> </ul> </li> <li>• symmetric failure calculations, short-circuit power</li> <li>• control in networks and power stations</li> <li>• grid protection</li> <li>• grid planning</li> <li>• power economy fundamentals</li> </ul>
<b>Literature</b>	K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Springer Vieweg, 9. Auflage, 2013 A. J. Schwab: "Elektroenergiesysteme", Springer, 7. Auflage, 2022 R. Flösdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008

Module M1802: Engineering Mechanics I (Stereostatics)			
Courses			
Title	Typ	Hrs/wk	CP
Engineering Mechanics I (Statics) (L1001)	Lecture	2	2
Engineering Mechanics I (Statics) (L1003)	Recitation Section (large)	2	2
Engineering Mechanics I (Statics) (L1002)	Recitation Section (small)	2	2
<b>Module Responsible</b>	Prof. Benedikt Kriegesmann		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Solid school knowledge in mathematics and physics.		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> The students can</p> <ul style="list-style-type: none"> <li>describe the axiomatic procedure used in mechanical contexts;</li> <li>explain important steps in model design;</li> <li>present technical knowledge in stereostatics.</li> </ul> <p><i>Skills</i> The students can</p> <ul style="list-style-type: none"> <li>explain the important elements of mathematical / mechanical analysis and model formation, and apply it to the context of their own problems;</li> <li>apply basic statical methods to engineering problems;</li> <li>estimate the reach and boundaries of statical methods and extend them to be applicable to wider problem sets.</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> The students can work in groups and support each other to overcome difficulties.</p> <p><i>Autonomy</i> Students are capable of determining their own strengths and weaknesses and to organize their time and learning based on those.</p>		
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90 min		
<b>Assignment for the Following Curricula</b>	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)	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Benedikt Kriegesmann
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Tasks in Mechanics</li> <li>• Modelling and model elements</li> <li>• Vector calculus for forces and torques</li> <li>• Forces and equilibrium in space</li> <li>• Constraints and reactions, characterization of constraint systems</li> <li>• Planar and spatial truss structures</li> <li>• Internal forces and moments for beams and frames</li> <li>• Center of mass, volumn, area and line</li> <li>• Computation of center of mass by intergals, joint bodies</li> <li>• Friction (sliding and sticking)</li> <li>• Friction of ropes</li> </ul>
<b>Literature</b>	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)	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Benedikt Kriegesmann
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	Forces and equilibrium Constraints and reactions Frames Center of mass Friction Internal forces and moments for beams
<b>Literature</b>	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)	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Benedikt Kriegesmann
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	Forces and equilibrium Constraints and reactions Frames Center of mass Friction Internal forces and moments for beams
<b>Literature</b>	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).

<b>Module M0568: Theoretical Electrical Engineering II: Time-Dependent Fields</b>			
<b>Courses</b>			
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
<b>Module Responsible</b>	Prof. Christian Schuster		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Electrical Engineering I, Electrical Engineering II, Theoretical Electrical Engineering I Mathematics I, Mathematics II, Mathematics III, Mathematics IV		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> 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).</p> <p><i>Autonomy</i> 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.</p>		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90-150 minutes		
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	5
<b>Workload in Hours</b>	Independent Study Time 108, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Christian Schuster
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- Theory and principal characteristics of quasistationary electromagnetic fields</li> <li>- Electromagnetic induction and law of induction</li> <li>- Skin effect and eddy currents</li> <li>- Shielding of time variable magnetic fields</li> <li>- Theory and principal characteristics of fully dynamic electromagnetic fields</li> <li>- Wave equations and properties of planar waves</li> <li>- Polarization and superposition of planar waves</li> <li>- Reflection and refraction of planar waves at boundary surfaces</li> <li>- Waveguide theory</li> <li>- Rectangular waveguide, planar optical waveguide</li> <li>- Electrical and magnetical dipol radiation</li> <li>- Simple arrays of antennas</li> </ul> <p>The practical application of numerical methods will be trained within specifically prepared lectures in an interactive manner using small MATLAB programs.</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- G. Lehner, "Elektromagnetische Feldtheorie: Für Ingenieure und Physiker", Springer (2010)</li> <li>- H. Henke, "Elektromagnetische Felder: Theorie und Anwendung", Springer (2011)</li> <li>- W. Nolting, "Grundkurs Theoretische Physik 3: Elektrodynamik", Springer (2011)</li> <li>- D. Griffiths, "Introduction to Electrodynamics", Pearson (2012)</li> <li>- J. Edminister, "Schaum's Outline of Electromagnetics", McGraw-Hill (2013)</li> <li>- Richard Feynman, "Feynman Lectures on Physics: Volume 2", Basic Books (2011)</li> </ul>

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

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
<b>Module Responsible</b>	Prof. Sabine Le Borne		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Mathematik I + II for Engineering Students (german or english) <b>or</b> Analysis &amp; Linear Algebra I + II for Technomathematicians</li> <li>• basic MATLAB/Python knowledge</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	Students are able to <ul style="list-style-type: none"> <li>• name numerical methods for interpolation, integration, least squares problems, eigenvalue problems, nonlinear root finding problems and to explain their core ideas,</li> <li>• repeat convergence statements for the numerical methods,</li> <li>• explain aspects for the practical execution of numerical methods with respect to computational and storage complexitx.</li> </ul>		
<i>Skills</i>	Students are able to <ul style="list-style-type: none"> <li>• implement, apply and compare numerical methods using MATLAB/Python,</li> <li>• justify the convergence behaviour of numerical methods with respect to the problem and solution algorithm,</li> <li>• select and execute a suitable solution approach for a given problem.</li> </ul>		
<b>Personal Competence</b>			
<i>Social Competence</i>	Students are able to <ul style="list-style-type: none"> <li>• 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.</li> </ul>		
<i>Autonomy</i>	Students are capable <ul style="list-style-type: none"> <li>• to assess whether the supporting theoretical and practical excercises are better solved individually or in a team,</li> <li>• to assess their individual progress and, if necessary, to ask questions and seek help.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90 minutes		
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Sabine Le Borne
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Finite precision arithmetic, error analysis, conditioning and stability</li> <li>2. Linear systems of equations: LU and Cholesky factorization, condition</li> <li>3. Interpolation: polynomial, spline and trigonometric interpolation</li> <li>4. Nonlinear equations: fixed point iteration, root finding algorithms, Newton's method</li> <li>5. Linear and nonlinear least squares problems: normal equations, Gram Schmidt and Householder orthogonalization, singular value decomposition, regularization, Gauss-Newton and Levenberg-Marquardt methods</li> <li>6. Eigenvalue problems: power iteration, inverse iteration, QR algorithm</li> <li>7. Numerical differentiation</li> <li>8. Numerical integration: Newton-Cotes rules, error estimates, Gauss quadrature, adaptive quadrature</li> </ol>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Gander/Gander/Kwok: Scientific Computing: An introduction using Maple and MATLAB, Springer (2014)</li> <li>• Stoer/Bulirsch: Numerische Mathematik 1, Springer</li> <li>• Dahmen, Reusken: Numerik für Ingenieure und Naturwissenschaftler, Springer</li> </ul>

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

Module M0675: Introduction to Communications and Random Processes			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>
Introduction to Communications and Random Processes (L0442)		Lecture	3
Introduction to Communications and Random Processes (L0443)		Recitation Section (large)	1
Introduction to Communications and Random Processes (L2354)		Recitation Section (small)	1
<b>Module Responsible</b>	Prof. Gerhard Bauch		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Mathematics 1-3</li> <li>• Signals and Systems</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	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.		
<i>Skills</i>	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.		
<b>Personal Competence</b>			
<i>Social Competence</i>	The students can jointly solve specific problems.		
<i>Autonomy</i>	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.		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90 min		
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory Data Science: Specialisation I. Mathematics/Computer Science: Elective Compulsory Electrical Engineering: Core Qualification: Compulsory Engineering Science: Specialisation Information and Communication Systems: Elective 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Gerhard Bauch
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction to communications engineering</li> <li>• Open Systems Interconnection (OSI) reference model</li> <li>• Components of a digital communications system</li> <li>• Fundamentals of signals and systems                             <ul style="list-style-type: none"> <li>◦ Analog and digital signals</li> <li>◦ Principles of Analog-to-digital (A/D) conversion</li> <li>◦ Deterministic and random signals</li> <li>◦ Power and energy of signals</li> <li>◦ Linear time-invariant (LTI) systems</li> <li>◦ Quadrature amplitude modulation (QAM)</li> </ul> </li> <li>• Introduction to stochastics</li> <li>• Probability theory                             <ul style="list-style-type: none"> <li>◦ Random experiments</li> <li>◦ Probability model, probability space, sample space</li> <li>◦ Definitions of probability                                     <ul style="list-style-type: none"> <li>▪ Probability according to Bernoulli/Laplace</li> <li>▪ Probability according to van Mises, relative frequency</li> <li>▪ Bertrand's paradox</li> <li>▪ Axiomatic definition of probability according to Kolmogorov</li> <li>▪ Probability of disjoint and non-disjoint events</li> <li>▪ Venn diagrams</li> </ul> </li> </ul> </li> </ul>

- Continuous and discrete random variables
  - Probability density function (pdf), cumulative 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-Khinchine 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 quantization, 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

	<ul style="list-style-type: none"> <li> <ul style="list-style-type: none"> <li>▪ SNR gain of DPCM over PCM</li> <li>▪ Delta modulation</li> </ul> </li> <li>• Fundamentals of information theory and coding           <ul style="list-style-type: none"> <li>◦ Definitions of information: Self-information, entropy</li> <li>◦ Binary entropy function</li> <li>◦ Source coding theorem</li> <li>◦ Source coding: Huffman code</li> <li>◦ Mutual information and channel capacity</li> <li>◦ Channel capacity of the AWGN channel and the binary input AWGN channel</li> <li>◦ Channel coding theorem</li> <li>◦ Principles of channel coding: Code rate and data rate, Hamming distance, minimum Hamming distance, error detection and error correction</li> <li>◦ Examples for channel codes: Block codes and convolutional codes, repetition code, single parity check code, Hamming code, Turbo codes</li> </ul> </li> <li>• Combinatorics           <ul style="list-style-type: none"> <li>◦ Variation with and without repetition</li> <li>◦ Combination with and without repetition</li> <li>◦ Permutation, Permutation of multisets</li> <li>◦ Word error probabilities of linear block codes</li> </ul> </li> <li>• Baseband transmission           <ul style="list-style-type: none"> <li>◦ Pulse shaping: Non-return to zero (NRZ) rectangular pulses, Manchester pulses, raised-cosine pulses, square-root raised-cosine pulses, Gaussian pulses</li> <li>◦ Transmit signal energy, average energy per symbol</li> <li>◦ Power spectral density (psd) of baseband signals</li> <li>◦ Definitions of signal bandwidth</li> <li>◦ Bandwidth efficiency</li> <li>◦ Intersymbol interference (ISI)</li> <li>◦ First and second Nyquist criterion</li> <li>◦ Eye patterns</li> <li>◦ Receive filter design: Matched filter</li> <li>◦ Matched-filter receiver and correlation receiver</li> <li>◦ Square-root Nyquist pulse shaping</li> <li>◦ Discrete-time AWGN channel model</li> </ul> </li> <li>• Maximum a posteriori probability (MAP) and maximum likelihood (ML) detection</li> <li>• Bit error probability in AWGN channels for binary antipodal and on-off signaling</li> <li>• Band-pass transmission via carrier modulation           <ul style="list-style-type: none"> <li>◦ Amplitude modulation, frequency modulation, phase modulation</li> <li>◦ Linear digital modulation methods: On-off keying (OOK), phase-shift keying (PSK), amplitude shift keying (ASK), quadrature amplitude shift keying (QAM)</li> </ul> </li> <li>•</li> </ul>
<p><b>Literature</b></p>	<p>K. Kammeyer: Nachrichtenübertragung, Teubner</p> <p>P.A. Höher: Grundlagen der digitalen Informationsübertragung, Teubner.</p> <p>M. Bossert: Einführung in die Nachrichtentechnik, Oldenbourg.</p> <p>J.G. Proakis, M. Salehi: Grundlagen der Kommunikationstechnik. Pearson Studium.</p> <p>J.G. Proakis, M. Salehi: Digital Communications. McGraw-Hill.</p> <p>S. Haykin: Communication Systems. Wiley</p> <p>J.G. Proakis, M. Salehi: Communication Systems Engineering. Prentice-Hall.</p> <p>J.G. Proakis, M. Salehi, G. Bauch, Contemporary Communication Systems. Cengage Learning.</p>

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

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

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	
<b>Module Responsible</b>	Prof. Hoc Khiem Trieu			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	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			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	Students are able <ul style="list-style-type: none"> <li>to represent the basics of semiconductor physics,</li> <li>to explain the operating principle of important semiconductor devices,</li> <li>to outline device characteristics and equivalent circuits as well as to explain their derivation and</li> <li>to discuss the limitation of device models.</li> </ul>			
<i>Skills</i>	Students are capable <ul style="list-style-type: none"> <li>to apply devices in basic circuits,</li> <li>to realize the physical context and to solve complex problems by oneself</li> </ul>			
<b>Personal Competence</b>				
<i>Social Competence</i>	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.			
<i>Autonomy</i>	Students are capable to acquire knowledge based on literature in order to prepare their experiments.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	10 %	Subject theoretical and practical work	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.
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 min			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Hoc Khiem Trieu
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>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)</li> <li>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)</li> <li>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)</li> <li>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)</li> </ul>
<b>Literature</b>	<p>S.M. Sze: Semiconductor devices, Physics and Technology, John Wiley &amp; Sons (1985) F. Thuselt: Physik der Halbleiterbauelemente, Springer (2011)</p> <p>T. Thille, D. Schmitt-Landsiedel: Mikroelektronik, Halbleiterbauelemente und deren Anwendung in elektronischen Schaltungen, Springer (2004)</p> <p>B.L. Anderson, R.L. Anderson: Fundamentals of Semiconductor Devices, McGraw-Hill (2005)</p> <p>D.A. Neamen: Semiconductor Physics and Devices, McGraw-Hill (2011)</p> <p>M. Shur: Introduction to Electronic Devices, John Wiley &amp; Sons (1996)</p> <p>S.M. Sze: Physics of semiconductor devices, John Wiley &amp; Sons (2007)</p> <p>H. Schaumburg: Halbleiter, B.G. Teubner (1991)</p> <p>A. Möschwitzer: Grundlagen der Halbleiter-&amp;Mikroelektronik, Bd1 Elektronische Halbleiterbauelemente, Carl Hanser (1992)</p> <p>H.-G. Unger, W. Schultz, G. Weinhausen: Elektronische Bauelemente und Netzwerke I, Physikalische Grundlagen der Halbleiterbauelemente, Vieweg (1985)</p>

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

<b>Module M0833: Introduction to Control Systems</b>			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Introduction to Control Systems (L0654)	Lecture	2	4
Introduction to Control Systems (L0655)	Recitation Section (small)	2	2
<b>Module Responsible</b>	Prof. Timm Faulwasser		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Representation of signals and systems in time and frequency domain, Laplace transform		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<ul style="list-style-type: none"> <li>• Students can represent dynamic system behavior in time and frequency domain, and can in particular explain properties of first and second order systems</li> <li>• They can explain the dynamics of simple control loops and interpret dynamic properties in terms of frequency response and root locus</li> <li>• They can explain the Nyquist stability criterion and the stability margins derived from it.</li> <li>• They can explain the role of the phase margin in analysis and synthesis of control loops</li> <li>• They can explain the way a PID controller affects a control loop in terms of its frequency response</li> <li>• They can explain issues arising when controllers designed in continuous time domain are implemented digitally</li> </ul>		
<i>Knowledge</i>			
<i>Skills</i>	<ul style="list-style-type: none"> <li>• Students can transform models of linear dynamic systems from time to frequency domain and vice versa</li> <li>• They can simulate and assess the behavior of systems and control loops</li> <li>• They can design PID controllers with the help of heuristic (Ziegler-Nichols) tuning rules</li> <li>• They can analyze and synthesize simple control loops with the help of root locus and frequency response techniques</li> <li>• They can calculate discrete-time approximations of controllers designed in continuous-time and use it for digital implementation</li> <li>• They can use standard software tools (Matlab Control Toolbox, Simulink) for carrying out these tasks</li> </ul>		
<b>Personal Competence</b>	<p style="margin-left: 20px;"><i>Social Competence</i> Students can work in small groups to jointly solve technical problems, and experimentally validate their controller designs</p> <p style="margin-left: 20px;"><i>Autonomy</i> Students can obtain information from provided sources (lecture notes, software documentation, experiment guides) and use it when solving given problems.</p> <p style="margin-left: 20px;">They can assess their knowledge in weekly on-line tests and thereby control their learning progress.</p>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	120 min		
<b>Assignment for the Following Curricula</b>	<p>General Engineering Science (German program, 7 semester): Core Qualification: Compulsory</p> <p>Bioprocess Engineering: Core Qualification: Compulsory</p> <p>Chemical and Bioprocess Engineering: Core Qualification: Compulsory</p> <p>Data Science: Specialisation II. Application: Elective Compulsory</p> <p>Electrical Engineering: Core Qualification: Compulsory</p> <p>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory</p> <p>Computer Science in Engineering: Core Qualification: Compulsory</p> <p>Integrated Building Technology: Core Qualification: Elective Compulsory</p> <p>Logistics and Mobility: Specialisation Information Technology: Elective Compulsory</p> <p>Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory</p> <p>Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory</p> <p>Mechanical Engineering: Core Qualification: Compulsory</p> <p>Mechatronics: Core Qualification: Compulsory</p> <p>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory</p> <p>Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory</p> <p>Process Engineering: Core Qualification: Compulsory</p> <p>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Information Technology: Elective Compulsory</p> <p>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Traffic Planning and Systems: Elective Compulsory</p> <p>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Elective Compulsory</p>		

Course L0654: Introduction to Control Systems	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Timm Faulwasser
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Signals and systems</p> <ul style="list-style-type: none"> <li>• Linear systems, differential equations and transfer functions</li> <li>• First and second order systems, poles and zeros, impulse and step response</li> <li>• Stability</li> </ul> <p>Feedback systems</p> <ul style="list-style-type: none"> <li>• Principle of feedback, open-loop versus closed-loop control</li> <li>• Reference tracking and disturbance rejection</li> <li>• Types of feedback, PID control</li> <li>• System type and steady-state error, error constants</li> <li>• Internal model principle</li> </ul> <p>Root locus techniques</p> <ul style="list-style-type: none"> <li>• Root locus plots</li> <li>• Root locus design of PID controllers</li> </ul> <p>Frequency response techniques</p> <ul style="list-style-type: none"> <li>• Bode diagram</li> <li>• Minimum and non-minimum phase systems</li> <li>• Nyquist plot, Nyquist stability criterion, phase and gain margin</li> <li>• Loop shaping, lead lag compensation</li> <li>• Frequency response interpretation of PID control</li> </ul> <p>Time delay systems</p> <ul style="list-style-type: none"> <li>• Root locus and frequency response of time delay systems</li> <li>• Smith predictor</li> </ul> <p>Digital control</p> <ul style="list-style-type: none"> <li>• Sampled-data systems, difference equations</li> <li>• Tustin approximation, digital implementation of PID controllers</li> </ul> <p>Software tools</p> <ul style="list-style-type: none"> <li>• Introduction to Matlab, Simulink, Control toolbox</li> <li>• Computer-based exercises throughout the course</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Werner, H., Lecture Notes „Introduction to Control Systems“</li> <li>• G.F. Franklin, J.D. Powell and A. Emami-Naeini "Feedback Control of Dynamic Systems", Addison Wesley, Reading, MA, 2009</li> <li>• K. Ogata "Modern Control Engineering", Fourth Edition, Prentice Hall, Upper Saddle River, NJ, 2010</li> <li>• R.C. Dorf and R.H. Bishop, "Modern Control Systems", Addison Wesley, Reading, MA 2010</li> </ul>

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

<b>Module M0834: Computernetworks and Internet Security</b>			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Computer Networks and Internet Security (L1098)	Lecture	3	5
Computer Networks and Internet Security (L1099)	Recitation Section (small)	1	1
<b>Module Responsible</b>	Prof. Andreas Timm-Giel		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basic of Computer Science		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i></p> <p>In this course, 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 and lecture discussions, these basic principles and an introduction to performance modelling are addressed using exercises, homework assignments and labs. This comprises of:</p> <ul style="list-style-type: none"> <li>• What's the Internet?</li> <li>• Application layer protocols (HTTP, SMTP, DNS)</li> <li>• Transport layer protocols (TCP, UDP)</li> <li>• Network Layer (Internet Protocol, routing in the Internet)</li> <li>• Data link layer with media access at the example of Ethernet and WLAN</li> <li>• Internet security: IPSec</li> <li>• Internet security: communication security, security of address resolution, firewalls</li> </ul> <p><i>Skills</i></p> <ul style="list-style-type: none"> <li>• Students are able to explain Internet protocols in detail and classify them</li> <li>• Students are able to analyze and develop networked systems in further studies and job</li> <li>• Students can apply their hands on experiences gained for networking protocols in real settings in further studies and job</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i></p> <ul style="list-style-type: none"> <li>• Students are able to work together in teams for labs and homework assignments. In doing so, they learn how to collaborate according to the needs of other students</li> <li>• Students are asked to explain the exercises and solutions within the team to determine how much content they have understood from the (pre-recorded) lectures. This fosters students' self-confidence and enhances their presentation skills</li> </ul> <p><i>Autonomy</i></p> <ul style="list-style-type: none"> <li>• Students can select relevant parts out of a high amount of professional knowledge and can independently learn and understand it</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	120 min		
<b>Assignment for the Following Curricula</b>	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 Electrical Engineering: Core Qualification: Elective Compulsory Engineering Science: Specialisation Mechatronics: Elective Compulsory Engineering Science: Specialisation Electrical Engineering: Elective Compulsory Engineering Science: Specialisation Information and Communication Systems: 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	5
<b>Workload in Hours</b>	Independent Study Time 108, Study Time in Lecture 42
<b>Lecturer</b>	Dr. Koojana Kuladinithi, Prof. Sibylle Fröschele
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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.</p> <p>In the second part of the lecture an introduction to Internet security is given.</p> <p>This class comprises:</p> <ul style="list-style-type: none"> <li>• Introduction to the Internet (TCP/IP model)</li> <li>• Application layer protocols (HTTP, SMTP, DNS)</li> <li>• Transport layer protocols (TCP, UDP)</li> <li>• Network Layer (Internet Protocol IPv4 &amp; IPv6, routing in the Internet)</li> <li>• Data link layer with media access at the example of WLAN</li> <li>• Introduction to Internet Security</li> <li>• Security Aspects of Address Resolution (DNS/DNSSEC, ARP/SEND)</li> <li>• Communication Security (IPSec) - From Address Resolution to Routing (Securing BGP)</li> <li>• Botnets + Firewalls</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Kurose, Ross, Computer Networking - A Top-Down Approach, 8th Edition, Addison-Wesley</li> <li>• Kurose, Ross, Computernetzwerke - Der Top-Down-Ansatz, Pearson Studium; Auflage: 8. Auflage</li> <li>• W. Stallings: Cryptography and Network Security: Principles and Practice, 8th edition</li> </ul> <p>Further literature is announced at the beginning of the lecture.</p>

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

Module M0634: Introduction into Medical Technology and Systems			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b> <b>CP</b>
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
<b>Module Responsible</b>	Prof. Alexander Schlaefer		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	principles of math (algebra, analysis/calculus) principles of stochastics principles of programming, R/Matlab		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	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.		
<i>Skills</i>	The students are able to evaluate systems and medical devices in the context of clinical applications.		
<b>Personal Competence</b>			
<i>Social Competence</i>	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.		
<i>Autonomy</i>	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.		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b> <b>Description</b>
	Yes	10 %	Written elaboration
	Yes	10 %	Presentation
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90 minutes		
<b>Assignment for the Following Curricula</b>	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 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 International Management and Engineering: Specialisation II. Medical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Medical Engineering: Elective Compulsory Mechatronics: Specialisation Medical Engineering: Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Alexander Schlaefer
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- imaging systems</li> <li>- computer aided surgery</li> <li>- medical sensor systems</li> <li>- medical information systems</li> <li>- regulatory affairs</li> <li>- standard in medical technology</li> </ul> <p>The students will work in groups to apply the methods introduced during the lecture using problem based learning.</p>
<b>Literature</b>	<p>Bernhard Priem, "Visual Computing for Medicine", 2014                      Heinz Handels, "Medizinische Bildverarbeitung", 2009 (<a href="https://katalog.tub.tuhh.de/Record/745558097">https://katalog.tub.tuhh.de/Record/745558097</a>)                      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 (<a href="https://katalog.tub.tuhh.de/Record/856571687">https://katalog.tub.tuhh.de/Record/856571687</a>)                      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</p>

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

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

Module M1803: Engineering Mechanics II (Elastostatics)			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b> <b>CP</b>
Engineering Mechanics II (Group Exercise) (L0494)		Recitation Section (small)	2              2
Engineering Mechanics II (Plenary Exercise) (L1691)		Recitation Section (large)	2              2
Engineering Mechanics II (Lecture) (L0493)		Lecture	2              2
<b>Module Responsible</b>	Prof. Christian Cyron		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	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)		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> Having accomplished this module, the students are able to</p> <ul style="list-style-type: none"> <li>- apply the fundamental concepts of mathematical and mechanical modeling and analysis to problems of their choice</li> <li>- apply the basic methods of elastostatics to problems of engineering, in particular in the design of mechanical structures</li> <li>- to educate themselves about more advanced aspects of elastostatics</li> </ul>		
<b>Personal Competence</b>	<p><i>Social Competence</i> Ability to communicate complex problems in elastostatics, to work out solution to these problems together with others, and to communicate these solutions.</p> <p><i>Autonomy</i> Self-discipline and endurance in tackling independently complex challenges in elastostatics; ability to learn also very abstract knowledge.</p>		
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90 min		
<b>Assignment for the Following Curricula</b>	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 L0494: Engineering Mechanics II (Group Exercise)	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Christian Cyron, Dr. Kevin Linka
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>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:</p> <ul style="list-style-type: none"> <li>• basis of continuum mechanics: stress, strain, constitutive laws</li> <li>• truss</li> <li>• torsion bar</li> <li>• beam theory: bending, moment of inertia of area, transverse shear</li> <li>• energy methods: Maxwell-Betti reciprocal work theorem, Castigliano's second theorem, theorem of Menabrea</li> <li>• strength of materials: maximum principle stress criterion, yield criteria according to Tresca and von Mises</li> <li>• stability of mechanical structures: Euler buckling strut</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Gross, D., Hauger, W., Schröder, J., Wall, W.A.: Technische Mechanik 1, Springer</li> <li>• Gross, D., Hauger, W., Schröder, J., Wall, W.A.: Technische Mechanik 2 Elastostatik, Springer</li> </ul>

Course L1691: Engineering Mechanics II (Plenary Exercise)	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Christian Cyron, Martin Legeland
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>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:</p> <ul style="list-style-type: none"> <li>• basis of continuum mechanics: stress, strain, constitutive laws</li> <li>• truss</li> <li>• torsion bar</li> <li>• beam theory: bending, moment of inertia of area, transverse shear</li> <li>• energy methods: Maxwell-Betti reciprocal work theorem, Castigliano's second theorem, theorem of Menabrea</li> <li>• strength of materials: maximum principle stress criterion, yield criteria according to Tresca and von Mises</li> <li>• stability of mechanical structures: Euler buckling strut</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Gross, D., Hauger, W., Schröder, J., Wall, W.A.: Technische Mechanik 1, Springer</li> <li>• Gross, D., Hauger, W., Schröder, J., Wall, W.A.: Technische Mechanik 2 Elastostatik, Springer</li> </ul>

Course L0493: Engineering Mechanics II (Lecture)	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Christian Cyron
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>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:</p> <ul style="list-style-type: none"> <li>• basis of continuum mechanics: stress, strain, constitutive laws</li> <li>• truss</li> <li>• torsion bar</li> <li>• beam theory: bending, moment of inertia of area, transverse shear</li> <li>• energy methods: Maxwell-Betti reciprocal work theorem, Castigliano's second theorem, theorem of Menabrea</li> <li>• strength of materials: maximum principle stress criterion, yield criteria according to Tresca and von Mises</li> <li>• stability of mechanical structures: Euler buckling strut</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Gross, D., Hauger, W., Schröder, J., Wall, W.A.: Technische Mechanik 1, Springer</li> <li>• Gross, D., Hauger, W., Schröder, J., Wall, W.A.: Technische Mechanik 2 Elastostatik, Springer</li> </ul>

<b>Module M0777: Semiconductor Circuit Design</b>			
<b>Courses</b>			
Title	Typ	Hrs/wk	CP
Semiconductor Circuit Design (L0763)	Lecture	3	4
Semiconductor Circuit Design (L0864)	Recitation Section (small)	1	2
<b>Module Responsible</b>	NN		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Fundamentals of electrical engineering Basics of physics, especially semiconductor physics		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>Students are able to explain the functionality of different MOS devices in electronic circuits.</li> <li>Students are able to explain how analog circuits functions and where they are applied.</li> <li>Students are able to explain the functionality of fundamental operational amplifiers and their specifications.</li> <li>Students know the fundamental digital logic circuits and can discuss their advantages and disadvantages.</li> <li>Students have knowledge about memory circuits and can explain their functionality and specifications.</li> <li>Students know the appropriate fields for the use of bipolar transistors.</li> </ul>		
<i>Skills</i>	<ul style="list-style-type: none"> <li>Students can calculate the specifications of different MOS devices and can define the parameters of electronic circuits.</li> <li>Students are able to develop different logic circuits and can design different types of logic circuits.</li> <li>Students can use MOS devices, operational amplifiers and bipolar transistors for specific applications.</li> </ul>		
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>Students are able work efficiently in heterogeneous teams.</li> <li>Students working together in small groups can solve problems and answer professional questions.</li> </ul>		
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>Students are able to assess their level of knowledge.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	120 min		
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory 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: Compulsory Engineering Science: Specialisation Mechatronics: Elective 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	NN
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Repetition Semiconductorphysics and Diodes</li> <li>• Functionality and characteristic curve of bipolar transistors</li> <li>• Basic circuits with bipolar transistors</li> <li>• Functionality and characteristic curve of MOS transistors</li> <li>• Basic circuits with MOS transistors for amplifiers</li> <li>• Operational amplifiers and their applications</li> <li>• Typical applications for analog and digital circuits</li> <li>• Realization of logical functions</li> <li>• Basic circuits with MOS transistors for combinational logic</li> <li>• Memory circuits</li> <li>• Basic circuits with MOS transistors for sequential logic</li> <li>• Basic concepts of analog-to-digital and digital-to-analog-converters</li> </ul>
<b>Literature</b>	<p>U. Tietze und Ch. Schenk, E. Gamm, Halbleiterschaltungstechnik, Springer Verlag, 14. Auflage, 2012, ISBN 3540428496</p> <p>R. J. Baker, CMOS - Circuit Design, Layout and Simulation, J. Wiley &amp; Sons Inc., 3. Auflage, 2011, ISBN: 0471700555</p> <p>H. Göbel, Einführung in die Halbleiter-Schaltungstechnik, Berlin, Heidelberg Springer-Verlag Berlin Heidelberg, 2011, ISBN: 9783642208874 ISBN: 9783642208867</p> <p>URL: <a href="http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10499499">http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10499499</a></p> <p>URL: <a href="http://dx.doi.org/10.1007/978-3-642-20887-4">http://dx.doi.org/10.1007/978-3-642-20887-4</a></p> <p>URL: <a href="http://ebooks.ciando.com/book/index.cfm/bok_id/319955">http://ebooks.ciando.com/book/index.cfm/bok_id/319955</a></p> <p>URL: <a href="http://www.ciando.com/img/bo">http://www.ciando.com/img/bo</a></p>

Course L0864: Semiconductor Circuit Design	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	NN, Weitere Mitarbeiter
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Basic circuits and characteristic curves of bipolar transistors</li> <li>• Basic circuits and characteristic curves of MOS transistors for amplifiers</li> <li>• Realization and dimensioning of operational amplifiers</li> <li>• Realization of logic functions</li> <li>• Basic circuits with MOS transistors for combinational and sequential logic</li> <li>• Memory circuits</li> <li>• Circuits for analog-to-digital and digital-to-analog converters</li> <li>• Design of exemplary circuits</li> </ul>
<b>Literature</b>	<p>U. Tietze und Ch. Schenk, E. Gamm, Halbleiterschaltungstechnik, Springer Verlag, 14. Auflage, 2012, ISBN 3540428496</p> <p>R. J. Baker, CMOS - Circuit Design, Layout and Simulation, J. Wiley &amp; Sons Inc., 3. Auflage, 2011, ISBN: 0471700555</p> <p>H. Göbel, Einführung in die Halbleiter-Schaltungstechnik, Berlin, Heidelberg Springer-Verlag Berlin Heidelberg, 2011, ISBN: 9783642208874 ISBN: 9783642208867</p> <p>URL: <a href="http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10499499">http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10499499</a></p> <p>URL: <a href="http://dx.doi.org/10.1007/978-3-642-20887-4">http://dx.doi.org/10.1007/978-3-642-20887-4</a></p> <p>URL: <a href="http://ebooks.ciando.com/book/index.cfm/bok_id/319955">http://ebooks.ciando.com/book/index.cfm/bok_id/319955</a></p> <p>URL: <a href="http://www.ciando.com/img/bo">http://www.ciando.com/img/bo</a></p>

Module M0803: Embedded Systems				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Embedded Systems (L0805)		Lecture	3	3
Embedded Systems (L2938)		Project-/problem-based Learning	1	1
Embedded Systems (L0806)		Recitation Section (small)	1	2
<b>Module Responsible</b>	Prof. Heiko Falk			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Computer Engineering			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> 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).</p> <p>Another part covers the hardware of embedded systems: Sensors, 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students are able to solve similar problems alone or in a group and to present the results accordingly.</p> <p><i>Autonomy</i> Students are able to acquire new knowledge from specific literature and to associate this knowledge with other classes.</p>			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	10 %	Subject	theoretical and practical work
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 minutes, contents of course and labs			
<b>Assignment for the Following Curricula</b>	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 Electrical Engineering: Elective Compulsory Engineering Science: Specialisation Information and Communication Systems: Compulsory Engineering Science: Specialisation Mechatronics: 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Heiko Falk
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction</li> <li>• Specifications and Modeling</li> <li>• Embedded/Cyber-Physical Systems Hardware</li> <li>• System Software</li> <li>• Evaluation and Validation</li> <li>• Mapping of Applications to Execution Platforms</li> <li>• Optimization</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Peter Marwedel. Embedded System Design - Embedded Systems Foundations of Cyber-Physical Systems. 2<sup>nd</sup> Edition, Springer, 2012., Springer, 2012.</li> </ul>

Course L2938: Embedded Systems	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Heiko Falk
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction</li> <li>• Specifications and Modeling</li> <li>• Embedded/Cyber-Physical Systems Hardware</li> <li>• System Software</li> <li>• Evaluation and Validation</li> <li>• Mapping of Applications to Execution Platforms</li> <li>• Optimization</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Peter Marwedel. Embedded System Design - Embedded Systems Foundations of Cyber-Physical Systems. 2<sup>nd</sup> Edition, Springer, 2012., Springer, 2012.</li> </ul>

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

## Thesis

### Module M-001: Bachelor Thesis

#### Courses

Title	Typ	Hrs/wk	CP
<b>Module Responsible</b>	Professoren der TUHH		
<b>Admission Requirements</b>	<ul style="list-style-type: none"> <li>According to General Regulations §21 (1):</li> </ul> <p>At least 126 ECTS credit points have to be achieved in study programme. The examinations board decides on exceptions.</p>		
<b>Recommended Previous Knowledge</b>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>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).</li> <li>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.</li> <li>The students are able to outline the state of research on a selected issue in their subject area.</li> </ul>		
<b>Skills</b>	<ul style="list-style-type: none"> <li>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.</li> <li>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.</li> <li>The students can take up a critical position on the findings of their own research work from a specialized perspective.</li> </ul>		
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>Both in writing and orally the students can outline a scientific issue for an expert audience accurately, understandably and in a structured way.</li> <li>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.</li> </ul>		
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>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.</li> <li>The students are able to identify, open up, and connect knowledge and material necessary for working on a scientific problem.</li> <li>The students can apply the essential techniques of scientific work to research of their own.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 360, Study Time in Lecture 0		
<b>Credit points</b>	12		
<b>Course achievement</b>	None		
<b>Examination</b>	Thesis		
<b>Examination duration and scale</b>	According to General Regulations		
<b>Assignment for the Following Curricula</b>	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		