TUHH

Hamburg University of Technology

# Module Manual

Bachelor of Science

# Electrical Engineering

Cohort: Winter Term 2018

Updated: 28th September 2018

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Hamburg University of Technology

# Module Manual

Bachelor

# Electrical Engineering

Cohort: Winter Term 2018

Updated: 28th September 2018

## Program description

### Content

# Core qualification

## Module M0575: Procedural Programming

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Procedural Programming (L0197) | Lecture | 1 | 2 |
| Procedural Programming (L0201) | Recitation Section (large) | 1 | 1 |
| Procedural Programming (L0202) | Practical Course | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Siegfried Rump |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Elementary PC handling skills<br>Elementary mathematical skills |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students acquire the following knowledge:<br>• They know basic elements of the programming language C. They know the basic data types and know how to use them.<br>• They have an understanding of elementary compiler tasks, of the preprocessor and programming environment and know how those interact.<br>• They know how to bind programs and how to include external libraries to enhance software packages.<br>• They know how to use header files and how to declare function interfaces to create larger programming projects.<br>• The acquire some knowledge how the program interacts with the operating system. This allows them to develop programs interacting with the programming environment as well.<br>• They learnt several possibilities how to model and implement frequently occurring standard algorithms. |
| *Skills* | • The students know how to judge the complexity of an algorithms and how to program algorithms efficiently.<br>• The students are able to model and implement algorithms for a number of standard functionalities. Moreover, they are able to adapt a given API. |

| | |
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| **Personal Competence** | |
| *Social Competence* | The students acquire the following skills:<br>• They are able to work in small teams to solve given weekly tasks, to identify and analyze programming errors and to present their results.<br>• They are able to explain simple phenomena to each other directly at the PC.<br>• They are able to plan and to work out a project in small teams.<br>• They communicate final results and present programs to their tutor. |
| *Autonomy* | • The students take individual examinations as well as a final written examn to prove their programming skills and ability to solve new tasks.<br>• The students have many possibilities to check their abilities when solving several given programming exercises.<br>• In order to solve the given tasks efficiently, the students have to split those appropriately within their group, where every student solves his or her part individually. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Studienleistung** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | Computer Science: Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Logistics and Mobility: Specialisation Engineering Science: Elective Compulsory<br>Mechatronics: Core qualification: Compulsory<br>Technomathematics: Core qualification: Compulsory |

| Course L0197: Procedural Programming | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Siegfried Rump |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • basic data types (integers, floating point format, ASCII-characters) and their dependencies on the CPU architecture<br>• advanced data types (pointers, arrays, strings, structs, lists)<br>• operators (arithmetical operations, logical operations, bit operations)<br>• control flow (choice, loops, jumps)<br>• preprocessor directives (macros, conditional compilation, modular design)<br>• functions (function definitions/interface, recursive functions, "call by value" versus "call by reference", function pointers)<br>• essential standard libraries and functions (stdio.h, stdlib.h, math.h, string.h, time.h)<br>• file concept, streams<br>• basic algorithms (sorting functions, series expansion, uniformly distributed permutation)<br>• exercise programs to deepen the programming skills |
| **Literature** | **Kernighan, Brian W** (Ritchie, Dennis M.;)<br>The C programming language<br>ISBN: 9780131103702<br>*Upper Saddle River, NJ [u.a.] : Prentice Hall PTR, 2009*<br><br>**Sedgewick, Robert**<br>Algorithms in C<br>ISBN: 0201316633<br>*Reading, Mass. [u.a.] : Addison-Wesley, 2007*<br><br>**Kaiser, Ulrich** (Kecher, Christoph.;)<br>C/C++: Von den Grundlagen zur professionellen Programmierung<br>ISBN: 9783898428392<br>*Bonn : Galileo Press, 2010*<br><br>**Wolf, Jürgen**<br>C von A bis Z : das umfassende Handbuch<br>ISBN: 3836214113<br>*Bonn : Galileo Press, 2009* |

| Course L0201: Procedural Programming | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Siegfried Rump |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0202: Procedural Programming | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Siegfried Rump |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

# Module M0577: Nontechnical Complementary Courses for Bachelors

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|---|---|
| **Module Responsible** | Dagmar Richter |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | None |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | **The Non-technical Academic Programms (NTA)**<br><br>imparts skills that, in view of the TUHH's training profile, professional engineering studies require but are not able to cover fully. Self-reliance, self-management, collaboration and professional and personnel management competences. The department implements these training objectives in its **teaching architecture**, in its **teaching and learning arrangements**, in **teaching areas** and by means of teaching offerings in which students can qualify by opting for **specific competences** and a **competence level** at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontechnical complementary courses.<br><br>**The Learning Architecture**<br><br>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.<br><br>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"<br><br>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.<br><br>**Teaching and Learning Arrangements**<br><br>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.<br><br>**Fields of Teaching**<br><br>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.<br><br>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.<br><br>**The Competence Level** |

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| | 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.<br><br>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. |
| *Skills* | **Specialized Competence (Knowledge)**<br><br>Students can<br><br>• locate selected specialized areas with the relevant non-technical mother discipline,<br>• outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area,<br>• different specialist disciplines relate to their own discipline and differentiate it as well as make connections,<br>• 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,<br>• Can communicate in a foreign language in a manner appropriate to the subject.<br><br>**Professional Competence (Skills)**<br><br>In selected sub-areas students can<br><br>• apply basic methods of the said scientific disciplines,<br>• auestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline,<br>• to handle simple questions in aforementioned scientific disciplines in a sucsessful manner,<br>• justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject. |
| **Personal Competence** | |
| *Social Competence* | **Personal Competences (Social Skills)**<br><br>Students will be able<br><br>• to learn to collaborate in different manner,<br>• to present and analyze problems in the abovementioned fields in a partner or group situation in a manner appropriate to the addressees,<br>• 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),<br>• to explain nontechnical items to auditorium with technical background knowledge. |
| *Autonomy* | **Personal Competences (Self-reliance)**<br><br>Students are able in selected areas<br><br>• to reflect on their own profession and professionalism in the context of real-life fields of application<br>• to organize themselves and their own learning processes<br>• to reflect and decide questions in front of a broad education background<br>• to communicate a nontechnical item in a competent way in writen form or verbaly<br>• to organize themselves as an entrepreneurial subject country (as far as this study-focus would be chosen) |
| **Workload in Hours** | Depends on choice of courses |

| Credit points | 6 |
|---|---|

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

# Module M0642: Physics for Engineers

## Courses

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

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|---|---|
| **Module Responsible** | Prof. Manfred Eich |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Calculus and linear algebra on high school level<br>• Physics on high school level |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can explain fundamental topics and laws of physics such as in the areas of mechanics, oscillations, waves, and optics.<br>Students can relate physics topics to technical problems. |
| *Skills* | Students can describe physical problems mathematically and solve such problems within the framework of their acquired mathematical expertise.<br>Students are able to write meaningful reports on experiments and to discuss the results in a conclusive way. |
| **Personal Competence** | |
| *Social Competence* | Students can jointly solve subject related problems in groups. They can present their results effectively within the framework of the problem solving and lab courses. |
| *Autonomy* | Students are capable to extract relevant information from the provided references and to relate this information to the content of the lecture. They can reflect their acquired level of expertise with the help of lecture accompanying measures such as exam typical exam questions. Students are able to connect their knowledge with that acquired from other lectures. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |

| **Studienleistung** | **Compulsory** | **Bonus** | **Form** | **Description** |
|---|---|---|---|---|
| | Yes | None | Subject theoretical and practical work | 4-seitige handschriftliche Versuchsvorbereitung, Ausarbeitung unter Anleitung und Testat |

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| **Examination** | Written exam |
| **Examination duration and scale** | 120 Minutes |

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| **Assignment for the Following Curricula** | General Engineering Science (German program): Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Compulsory |

| **Course L0367: Physics for Engineers** | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Manfred Eich |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction<br>• Kinematics and dynamics<br>• Work, Energy, momentum<br>• Rotatory Motion, moments of inertia<br>• Gravitation<br>• Special Theory of Relativity<br>• Oscillations<br>• Waves<br>• Geometrical optics<br>• Wave optics<br>• Matter waves<br>• Fundamentals of quantum mechanics |
| **Literature** | • Giancoli, Physics for Scientists & Engineers Vol. 1, 2, Pearson<br>• Halliday/Resnik/Walker, *Fundamentals of physics*, Wiley<br>• K. Cummings, P. Laws, E. Redish, and P. Cooney (“CLRC”), *Understanding Physics*, Wiley<br>• Gerthsen/Vogel, *Physik*, Springer Verlag<br>• Hering/Martin/Stohrer, *Physik für Ingenieure*, VDI-Verlag |

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

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

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

## Courses

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

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|---|---|
| **Module Responsible** | Prof. Manfred Kasper |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | |
| *Skills* | |
| **Personal Competence** | |
| *Social Competence* | |
| *Autonomy* | |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |

**Studienleistung**

| Compulsory | Bonus | Form | Description |
|---|---|---|---|
| No | 10 % | Excercises | |

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|---|---|
| **Examination** | Written exam |
| **Examination duration and scale** | zweistündig |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Core qualification: Compulsory<br>General Engineering Science (German program, 7 semester): Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Mechatronics: Core qualification: Compulsory |

| Course L0675: Electrical Engineering I: Direct Current Networks and Electromagnetic Fields | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 5 |
| **Workload in Hours** | Independent Study Time 108, Study Time in Lecture 42 |
| **Lecturer** | Prof. Manfred Kasper |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | 1. M. Kasper, Skript zur Vorlesung Elektrotechnik 1, 2013<br>2. M. Albach: Grundlagen der Elektrotechnik 1, Pearson Education, 2004<br>3. F. Moeller, H. Frohne, K.H. Löcherer, H. Müller: Grundlagen der Elektrotechnik, Teubner, 2005<br>4. A. R. Hambley: Electrical Engineering, Principles and Applications, Pearson Education, 2008 |

| Course L0676: Electrical Engineering I: Direct Current Networks and Electromagnetic Fields | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 2, Study Time in Lecture 28 |
| **Lecturer** | Prof. Manfred Kasper |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | 1. Übungsaufgaben zur Elektrotechnik 1, TUHH, 2013<br>2. Ch. Kautz: Tutorien zur Elektrotechnik, Pearson Studium, 2010 |

# Module M0829: Foundations of Management

## Courses

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

| | |
|---|---|
| **Module Responsible** | Prof. Christoph Ihl |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic Knowledge of Mathematics and Business |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After taking this module, students know the important basics of many different areas in Business and Management, from Planning and Organisation to Marketing and Innovation, and also to Investment and Controlling. In particular they are able to<br>• explain the differences between Economics and Management and the sub-disciplines in Management and to name important definitions from the field of Management<br>• explain the most important aspects of and goals in Management and name the most important aspects of entreprneurial projects<br>• describe and explain basic business functions as production, procurement and sourcing, supply chain management, organization and human ressource management, information management, innovation management and marketing<br>• 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<br>• state basics from accounting and costing and selected controlling methods. |
| *Skills* | Students are able to analyse business units with respect to different criteria (organization, objectives, strategies etc.) and to carry out an Entrepreneurship project in a team. In particular, they are able to<br>• analyse Management goals and structure them appropriately<br>• analyse organisational and staff structures of companies<br>• apply methods for decision making under multiple objectives, under uncertainty and under risk<br>• analyse production and procurement systems and Business information systems<br>• analyse and apply basic methods of marketing<br>• select and apply basic methods from mathematical finance to predefined problems<br>• apply basic methods from accounting, costing and controlling to predefined problems |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>• work successfully in a team of students<br>• to apply their knowledge from the lecture to an entrepreneurship project and write a coherent report on the project<br>• to communicate appropriately and<br>• to cooperate respectfully with their fellow students. |
| | Students are able to |

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|---|---|
| *Autonomy* | • work in a team and to organize the team themselves<br>• to write a report on their project. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Studienleistung** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | several written exams during the semester |
| | General Engineering Science (German program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Computer Science: Compulsory<br>General Engineering Science (German program): Specialisation Process Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Civil- and Enviromental Engeneering: Compulsory<br>General Engineering Science (German program): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Civil Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>Civil- and Environmental Engineering: Core qualification: Compulsory<br>Bioprocess Engineering: Core qualification: Compulsory |

| | |
|---|---|
| **Assignment for the Following Curricula** | Computer Science: Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Civil- and Enviromental Engeneering: Compulsory<br>General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Computer Science: Compulsory<br>General Engineering Science (English program): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (English program): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Computer Science: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Civil Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Logistics and Mobility: Core qualification: Compulsory<br>Mechanical Engineering: Core qualification: Compulsory<br>Mechatronics: Core qualification: Compulsory<br>Naval Architecture: Core qualification: Compulsory<br>Technomathematics: Core qualification: Compulsory<br>~~Process Engineering: Core qualification: Compulsory~~ |

| Course L0882: Management Tutorial | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christoph Ihl, Katharina Roedelius, Tobias Vlcek |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | In the management tutorial, the contents of the lecture will be deepened by practical examples and the application of the discussed tools.<br><br>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 self-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. |
| **Literature** | Relevante Literatur aus der korrespondierenden Vorlesung. |

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

# Module M0850: Mathematics I

## Courses

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Analysis I (L1010) | Lecture | 2 | 2 |
| Analysis I (L1012) | Recitation Section (small) | 1 | 1 |
| Analysis I (L1013) | Recitation Section (large) | 1 | 1 |
| Linear Algebra I (L0912) | Lecture | 2 | 2 |
| Linear Algebra I (L0913) | Recitation Section (small) | 1 | 1 |
| Linear Algebra I (L0914) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Anusch Taraz |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | School mathematics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can name the basic concepts in analysis and linear algebra. They are able to explain them using appropriate examples.<br>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.<br>• They know proof strategies and can reproduce them. |
| *Skills* | • Students can model problems in analysis and linear algebra with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods.<br>• Students are able to discover and verify further logical connections between the concepts studied in the course.<br>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results. |
| **Personal Competence** | |
| *Social Competence* | • Students are able to work together in teams. They are capable to use mathematics as a common language.<br>• In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers. |
| *Autonomy* | • Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.<br>• Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems. |

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|---|---|
| **Workload in Hours** | Independent Study Time 128, Study Time in Lecture 112 |
| **Credit points** | 8 |
| **Studienleistung** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min (Analysis I) + 60 min (Linear Algebra I) |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Core qualification: Compulsory<br>General Engineering Science (German program, 7 semester): Core qualification: Compulsory<br>Civil- and Environmental Engineering: Core qualification: Compulsory<br>Bioprocess Engineering: Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Logistics and Mobility: Core qualification: Compulsory<br>Mechanical Engineering: Core qualification: Compulsory<br>Mechatronics: Core qualification: Compulsory<br>Naval Architecture: Core qualification: Compulsory<br>Process Engineering: Core qualification: Compulsory |

| **Course L1010: Analysis I** | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des Fachbereiches Mathematik der UHH |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Foundations of differential and integrational calculus of one variable<br>• statements, sets and functions<br>• natural and real numbers<br>• convergence of sequences and series<br>• continuous and differentiable functions<br>• mean value theorems<br>• Taylor series<br>• calculus<br>• error analysis<br>• fixpoint iteration |
| **Literature** | • http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html |

| Course L1012: Analysis I | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dozenten des Fachbereiches Mathematik der UHH |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1013: Analysis I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dozenten des Fachbereiches Mathematik der UHH |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0912: Linear Algebra I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Anusch Taraz, Prof. Marko Lindner |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • vectors: intuition, rules, inner and cross product, lines and planes<br>• systems of linear equations: Gauß elimination, matrix product, inverse matrices, transformations, block matrices, determinants<br>• orthogonal projection in R^n, Gram-Schmidt-Orthonormalization |
| **Literature** | • T. Arens u.a. : Mathematik, Spektrum Akademischer Verlag, Heidelberg 2009<br>• W. Mackens, H. Voß: Mathematik I für Studierende der Ingenieurwissenschaften, HECO-Verlag, Alsdorf 1994<br>• W. Mackens, H. Voß: Aufgaben und Lösungen zur Mathematik I für Studierende der Ingenieurwissenschaften, HECO-Verlag, Alsdorf 1994<br>• G. Strang: Lineare Algebra, Springer-Verlag, 2003<br>• G. und S. Teschl: Mathematik für Informatiker, Band 1, Springer-Verlag, 2013 |

| Course L0913: Linear Algebra I | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Anusch Taraz, Prof. Marko Lindner |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • vectors: intuition, rules, inner and cross product, lines and planes<br>• general vector spaces: subspaces, Euclidean vector spaces<br>• systems of linear equations: Gauß-elimination, matrix product, inverse matrices, transformations, LR-decomposition, block matrices, determinants |
| **Literature** | • T. Arens u.a. : Mathematik, Spektrum Akademischer Verlag, Heidelberg 2009<br>• W. Mackens, H. Voß: Mathematik I für Studierende der Ingenieurwissenschaften, HECO-Verlag, Alsdorf 1994<br>• W. Mackens, H. Voß: Aufgaben und Lösungen zur Mathematik I für Studierende der Ingenieurwissenschaften, HECO-Verlag, Alsdorf 1994 |

| Course L0914: Linear Algebra I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Christian Seifert |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

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

## Courses

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

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|---|---|
| **Module Responsible** | Prof. Christian Becker |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Electrical Engineering I<br>Mathematics I<br>Direct current networks, complex numbers |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to reproduce and explain fundamental theories, principles, and methods related to the theory of alternating currents. They can describe networks of linear elements using a complex notation for voltages and currents. They can reproduce an overview of applications for the theory of alternating currents in the area of electrical engineering. Students are capable of explaining the behavior of fundamental passive and active devices as well as their impact on simple circuits. |
| *Skills* | Students are capable of calculating parameters within simple electrical networks at alternating currents by means of a complex notation for voltages and currents. They can appraise the fundamental effects that may occur within electrical networks at alternating currents. Students are able to analyze simple circuits such as oscillating circuits, filter, and matching networks quantitatively and dimension elements by means of a design. They can motivate and justify the fundamental elements of an electrical power supply (transformer, transmission line, compensation of reactive power, multiphase system) and are qualified to dimension their main features. |
| **Personal Competence** | |
| *Social Competence* | Students are able to work together on subject related tasks in small groups. They are able to present their results effectively. |
| *Autonomy* | Students are capable to gather necessary information from the references provided and relate that information to the context of the lecture. They are able to continually reflect their knowledge by means of activities that accompany the lecture, such as online-tests and exercises that are related to the exam. Based on respective feedback, students are expected to adjust their individual learning process. They are able to draw connections between their knowledge obtained in this lecture and the content of other lectures (e.g. Electrical Engineering I, Linear Algebra, and Analysis). |

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| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Studienleistung** | **Compulsory** **Bonus** **Form** **Description**<br>No 10 % Midterm |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 - 150 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Core qualification: Compulsory<br>General Engineering Science (German program, 7 semester): Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Mechatronics: Core qualification: Compulsory |

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

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

# Module M0553: Objectoriented Programming, Algorithms and Data Structures

## Courses

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Objectoriented Programming, Algorithms and Data Structures (L0131) | Lecture | 4 | 4 |
| Objectoriented Programming, Algorithms and Data Structures (L0132) | Recitation Section (small) | 1 | 2 |

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|---|---|
| **Module Responsible** | Prof. Rolf-Rainer Grigat |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Lecture Prozedurale Programmierung or equivalent proficiency in imperative programming<br><br>Mandatory prerequisite for this lecture is proficiency in imperative programming (C, Pascal, Fortran or similar). You should be familiar with simple data types (integer, double, char), arrays, if-then-else, for, while, procedure calls or function calls, pointers, and you should have used all those in your own programs and therefore should be proficient with editor, compiler, linker and debugger. In this lecture we will immediately start with the introduction of objects and we will not repeat the basics mentioned above.<br><br>This remark is especially important for AIW, GES, LUM because those prerequisites are **not** part of the curriculum. They are prerequisites for the start of those curricula in general. The programs ET, CI and IIW include those prerequisites in the first semester in the lecture Prozedurale Programmierung.<br><br>. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can explain the essentials of software design and the design of a class architecture with reference to existing class libraries and design patterns.<br><br>Students can describe fundamental data structures of discrete mathematics and assess the complexity of important algorithms for sorting and searching. |
| *Skills* | Students are able to<br><br>• Design software using given design patterns and applying class hierarchies and polymorphism<br>• Carry out software development and tests using version management systems and Google Test<br>• Sort and search for data efficiently<br>• Assess the complexity of algorithms. |
| **Personal Competence** | |
| *Social Competence* | Students can work in teams and communicate in forums. |
| *Autonomy* | Students are able to solve programming tasks such as LZW data compression using SVN Repository and Google Test independently and over a period of two to three weeks. |

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| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Studienleistung** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 Minutes, Content of Lecture, exercises and material in StudIP |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Computer Science: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory<br>Computer Science: Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Computer Science: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Computer Science: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Logistics and Mobility: Specialisation Engineering Science: Elective Compulsory<br>Technomathematics: Core qualification: Compulsory |

| **Course L0131: Objectoriented Programming, Algorithms and Data Structures** | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 4 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 64, Study Time in Lecture 56 |
| **Lecturer** | Prof. Rolf-Rainer Grigat |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | **Object oriented analysis and design:**<br>• Objectoriented programming in C++ and Java<br>• generic programming<br>• UML<br>• design patterns<br>**Data structures and algorithmes:**<br>• complexity of algorithms<br>• searching, sorting, hash tables,<br>• stack, queues, lists,<br>• trees (AVL, heap, 2-3-4, Trie, Huffman, Patricia, B),<br>• sets, priority queues,<br>• directed and undirected graphs (spanning trees, shortest and longest path) |
| **Literature** | Skriptum |

| Course L0132: Objectoriented Programming, Algorithms and Data Structures | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Rolf-Rainer Grigat |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

# Module M0748: Materials in Electrical Engineering

## Courses

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

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

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|---|---|
| | Engineering: Compulsory<br>Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory |

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

| Course L0685: Materials in Electrical Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Manfred Eich |
| **Language** | DE |
| **Cycle** | SoSe |
| | The Hamiltonian approach to classical mechanics. Analysis of a simple oscillator. |

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

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

# Module M0851: Mathematics II

## Courses

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Analysis II (L1025) | Lecture | 2 | 2 |
| Analysis II (L1026) | Recitation Section (large) | 1 | 1 |
| Analysis II (L1027) | Recitation Section (small) | 1 | 1 |
| Linear Algebra II (L0915) | Lecture | 2 | 2 |
| Linear Algebra II (L0916) | Recitation Section (small) | 1 | 1 |
| Linear Algebra II (L0917) | Recitation Section (large) | 1 | 1 |

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|---|---|
| **Module Responsible** | Prof. Anusch Taraz |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mathematics I |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can name further concepts in analysis and linear algebra. They are able to explain them using appropriate examples.<br>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.<br>• They know proof strategies and can reproduce them. |
| *Skills* | • Students can model problems in analysis and linear algebra with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods.<br>• Students are able to discover and verify further logical connections between the concepts studied in the course.<br>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results. |
| **Personal Competence** | |
| *Social Competence* | • Students are able to work together in teams. They are capable to use mathematics as a common language.<br>• In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers. |
| *Autonomy* | • Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.<br>• Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems. |

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|---|---|
| **Workload in Hours** | Independent Study Time 128, Study Time in Lecture 112 |
| **Credit points** | 8 |
| **Studienleistung** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min (Analysis II) + 60 min (Linear Algebra II) |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Core qualification: Compulsory<br>General Engineering Science (German program, 7 semester): Core qualification: Compulsory<br>Civil- and Environmental Engineering: Core qualification: Compulsory<br>Bioprocess Engineering: Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Logistics and Mobility: Core qualification: Compulsory<br>Mechanical Engineering: Core qualification: Compulsory<br>Mechatronics: Core qualification: Compulsory<br>Naval Architecture: Core qualification: Compulsory<br>Process Engineering: Core qualification: Compulsory |

| **Course L1025: Analysis II** | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des Fachbereiches Mathematik der UHH |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • power series and elementary functions<br>• interpolation<br>• integration (proper integrals, fundamental theorem, integration rules, improper integrals, parameter dependent integrals<br>• applications of integration (volume and surface of bodies of revolution, lines and arc length, line integrals<br>• numerical quadrature<br>• periodic functions |
| **Literature** | • http://www.math.uni-hamburg.de/teaching/export/tuhh/index.html |

| Course L1026: Analysis II | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dozenten des Fachbereiches Mathematik der UHH |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1027: Analysis II | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dozenten des Fachbereiches Mathematik der UHH |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0915: Linear Algebra II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Anusch Taraz, Prof. Marko Lindner |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • general vector spaces: subspaces, Euclidean vector spaces<br>• linear mappings: basis transformation, orthogonal projection, orthogonal matrices, householder matrices<br>• linear regression: normal equations, linear discrete approximation<br>• eigenvalues: diagonalising matrices, normal matrices, symmetric and Hermite matrices<br>• system of linear differential equations<br>• matrix factorizations: LR-decomposition, QR-decomposition, Schur decomposition, Jordan normal form, singular value decomposition |
| **Literature** | • T. Arens u.a. : Mathematik, Spektrum Akademischer Verlag, Heidelberg 2009<br>• W. Mackens, H. Voß: Mathematik I für Studierende der Ingenieurwissenschaften, HECO-Verlag, Alsdorf 1994<br>• W. Mackens, H. Voß: Aufgaben und Lösungen zur Mathematik I für Studierende der Ingenieurwissenschaften, HECO-Verlag, Alsdorf 1994<br>• G. Strang: Lineare Algebra, Springer-Verlag, 2003<br>• G. und S. Teschl: Mathematik für Informatiker, Band 1, Springer-Verlag, 2013 |

| Course L0916: Linear Algebra II | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Anusch Taraz, Prof. Marko Lindner |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • linear mappings: basis transformation, orthogonal projection, orthogonal matrices, householder matrices<br>• linear regression: QR-decomposition, normal equations, linear discrete approximation<br>• eigenvalues: diagonalising matrices, normal matrices, symmetric and Hermite matrices, Jordan normal form, singular value decomposition<br>• system of linear differential equations |
| **Literature** | • W. Mackens, H. Voß: Mathematik I für Studierende der Ingenieurwissenschaften, HECO-Verlag, Alsdorf 1994<br>• W. Mackens, H. Voß: Aufgaben und Lösungen zur Mathematik I für Studierende der Ingenieurwissenschaften, HECO-Verlag, Alsdorf 1994 |

| Course L0917: Linear Algebra II | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Anusch Taraz, Prof. Marko Lindner, Dr. Christian Seifert |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

# Module M0783: Measurements: Methods and Data Processing

## Courses

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

| | |
|---|---|
| **Module Responsible** | Prof. Alexander Schlaefer |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | principles of mathematics<br>principles of electrical engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are able to explain the purpose of metrology and the acquisition and processing of measurements. They can detail aspects of probability theory and errors, and explain the processing of stochastic signals. Students know methods to digitalize and describe measured signals. |
| *Skills* | The students are able to evaluate problems of metrology and to apply methods for describing and processing of measurements. |
| **Personal Competence** | |
| *Social Competence* | The students solve problems in small groups. |
| *Autonomy* | The students can reflect their knowledge and discuss and evaluate their results. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |

| **Studienleistung** | **Compulsory** | **Bonus** | **Form** | **Description** |
|---|---|---|---|---|
| | Yes | 10 % | Excercises | |

| | |
|---|---|
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory |

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|---|---|
| | Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory<br>Computational Science and Engineering: Specialisation Computer Science: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Technomathematics: Core qualification: Elective Compulsory |

| **Course L0781: EE Experimental Lab** | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Alexander Schlaefer, Prof. Christian Schuster, Prof. Thanh Trung Do, Prof. Rolf-Rainer Grigat, Prof. Arne Jacob, Prof. Herbert Werner, Dozenten des SD E, Prof. Heiko Falk |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | lab experiments: digital circuits, semiconductors, micro controllers, analog circuits, AC power, electrical machines |
| **Literature** | Wird in der Lehrveranstaltung festgelegt |

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

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

# Module M0708: Electrical Engineering III: Circuit Theory and Transients

## Courses

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

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

| | |
|---|---|
| **Assignment for the Following Curricula** | Focus Mechatronics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory<br>Computational Science and Engineering: Specialisation Mathematics & Engineering Science: Elective Compulsory<br>Mechatronics: Core qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

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

| Course L0567: Circuit Theory | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Arne Jacob |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | see interlocking course |
| **Literature** | siehe korrespondierende Lehrveranstaltung<br><br>see interlocking course |

# Module M0730: Computer Engineering

## Courses

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

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|---|---|
| **Module Responsible** | Prof. Heiko Falk |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge in electrical engineering<br><br>The successful completion of the labs will be honored during the evaluation of the module's examination according to the following rules:<br><br>1. Upon a passed module examination, the student is granted a bonus on the examination's marks due to the successful labs, such that the examination's marks are lifted by 0,3 or 0,4, respectively, up to the next-better grade.<br>2. The improvement of the grade 5,0 up to 4,3 and of 4,3 up to 4,0 is not possible. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | This module deals with the foundations of the functionality of computing systems. It covers the layers from the assembly-level programming down to gates. The module includes the following topics:<br><br>• Introduction<br>• Combinational logic: Gates, Boolean algebra, Boolean functions, hardware synthesis, combinational networks<br>• Sequential logic: Flip-flops, automata, systematic hardware design<br>• Technological foundations<br>• Computer arithmetic: Integer addition, subtraction, multiplication and division<br>• Basics of computer architecture: Programming models, MIPS single-cycle architecture, pipelining<br>• Memories: Memory hierarchies, SRAM, DRAM, caches<br>• Input/output: I/O from the perspective of the CPU, principles of passing data, point-to-point connections, busses |
| *Skills* | The students perceive computer systems from the architect's perspective, i.e., they identify the internal structure and the physical composition of computer systems. The students can analyze, how highly specific and individual computers can be built based on a collection of few and simple components. They are able to distinguish between and to explain the different abstraction layers of today's computing systems - from gates and circuits up to complete processors.<br><br>After successful completion of the module, the students are able to judge the interdependencies between a physical computer system and the software executed on it. In particular, they shall understand the consequences that the execution of software has on the hardware-centric abstraction layers from the assembly language down to gates. This way, they will be enabled to evaluate the impact that these low abstraction levels have on an entire system's performance and to propose feasible options. |
| **Personal Competence** | |
| *Social Competence* | Students are able to solve similar problems alone or in a group and to present the results accordingly. |

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| *Autonomy* | Students are able to acquire new knowledge from specific literature and to associate this knowledge with other classes. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Studienleistung** | **Compulsory** **Bonus** **Form** **Description**<br>Yes 10 % Excercises |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes, contents of course and labs |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Core qualification: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Civil Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>Computer Science: Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Core qualification: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Computer Science: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Civil Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Process |

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| | Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Mechatronics: Core qualification: Compulsory<br>Technomathematics: Specialisation II. Informatics: Elective Compulsory |

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

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

# Module M0853: Mathematics III

## Courses

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

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|---|---|
| **Module Responsible** | Prof. Anusch Taraz |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mathematics I + II |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can name the basic concepts in the area of analysis and differential equations. They are able to explain them using appropriate examples.<br>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.<br>• They know proof strategies and can reproduce them. |
| *Skills* | • Students can model problems in the area of analysis and differential equations with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods.<br>• Students are able to discover and verify further logical connections between the concepts studied in the course.<br>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results. |
| **Personal Competence** | |
| *Social Competence* | • Students are able to work together in teams. They are capable to use mathematics as a common language.<br>• In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers. |
| *Autonomy* | • Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.<br>• Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems. |

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| **Workload in Hours** | Independent Study Time 128, Study Time in Lecture 112 |
| **Credit points** | 8 |
| **Studienleistung** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min (Analysis III) + 60 min (Differential Equations 1) |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Core qualification: Compulsory<br>General Engineering Science (German program, 7 semester): Core qualification: Compulsory<br>Civil- and Environmental Engineering: Core qualification: Compulsory<br>Bioprocess Engineering: Core qualification: Compulsory<br>Computer Science: Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Core qualification: Compulsory<br>General Engineering Science (English program, 7 semester): Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Mechanical Engineering: Core qualification: Compulsory<br>Mechatronics: Core qualification: Compulsory<br>Naval Architecture: Core qualification: Compulsory<br>Process Engineering: Core qualification: Compulsory |

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

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

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

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

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

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

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

## Courses

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

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

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| **Examination duration and scale** | 90-150 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>Computational Science and Engineering: Specialisation Mathematics & Engineering Science: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

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

| Course L0181: Theoretical Electrical Engineering I: Time-Independent Fields | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 2, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Schuster |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | - Maxwell's Equations in integral and differential notation<br>- Boundary conditions<br>- Laws of conservation for energy and charge<br>- Classification of electromagnetic field properties<br>- Integral characteristics of time-independent fields (R, L, C)<br>- Generic approaches to solving Poisson's Equation<br>- Electrostatic fields and specific methods of solving<br>- Magnetostatic fields and specific methods of solving<br>- Fields of electrical current density and specific methods of solving<br>- Action of force within time-independent fields<br>- Numerical methods for solving time-independent problems |
| **Literature** | - G. Lehner, "Elektromagnetische Feldtheorie: Für Ingenieure und Physiker", Springer (2010)<br>- H. Henke, "Elektromagnetische Felder: Theorie und Anwendung", Springer (2011)<br>- W. Nolting, "Grundkurs Theoretische Physik 3: Elektrodynamik", Springer (2011)<br>- D. Griffiths, "Introduction to Electrodynamics", Pearson (2012)<br>- J. Edminister, " Schaum's Outline of Electromagnetics", Mcgraw-Hill (2013)<br>- Richard Feynman, "Feynman Lectures on Physics: Volume 2", Basic Books (2011) |

# Module M0672: Signals and Systems

## Courses

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

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

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|---|---|
| | Compulsory<br>General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>Computer Science: Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Compulsory |
| **Assignment for the Following Curricula** | General Engineering Science (English program): Specialisation Civil- and Enviromental Engeneering: Compulsory<br>General Engineering Science (English program): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Computer Science: Compulsory<br>General Engineering Science (English program): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Computer Science: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory |

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|---|---|
| | General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Mechatronics: Core qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| Course L0432: Signals and Systems | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Gerhard Bauch |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | • Basic classification and description of continuous-time and discrete-time signals and systems<br>• Concvolution<br>• Power and energy of signals<br>• Correlation functions of deterministic signals<br>• Linear time-invariant (LTI) systems<br>• Signal transformations:<br>  ◦ Fourier-Series<br>  ◦ Fourier Transform<br>  ◦ Laplace Transform<br>  ◦ Discrete-time Fourier Transform<br>  ◦ Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT)<br>  ◦ Z-Transform<br>• Analysis and design of LTI systems in time and frequency domain<br>• Basic filter types<br>• Sampling, sampling theorem<br>• Fundamentals of recursive and non-recursive discrete-time filters |
| **Literature** | • T. Frey , M. Bossert , Signal- und Systemtheorie, B.G. Teubner Verlag 2004<br>• K. Kammeyer, K. Kroschel, Digitale Signalverarbeitung, Teubner Verlag.<br>• B. Girod ,R. Rabensteiner , A. Stenger , Einführung in die Systemtheorie, B.G. Teubner, Stuttgart, 1997<br>• J.R. Ohm, H.D. Lüke , Signalübertragung, Springer-Verlag 8. Auflage, 2002<br>• S. Haykin, B. van Veen: Signals and systems. Wiley.<br>• Oppenheim, A.S. Willsky: Signals and Systems. Pearson.<br>• Oppenheim, R. W. Schafer: Discrete-time signal processing. Pearson. |

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

# Module M0709: Electrical Engineering IV: Transmission Lines and Research Seminar

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Research Seminar Electrical Engineering, Computer Science, Mathematics (L0571) | Seminar | 2 | 2 |
| Transmission Line Theory (L0570) | Lecture | 2 | 3 |
| Transmission Line Theory (L0572) | Recitation Section (large) | 2 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Arne Jacob |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Electrical Engineering I-III, Mathematics I-III |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can explain the fundamentals of wave propagation on transmission lines at low and high frequencies. They are able to analyze circuits with transmission lines in time and frequency domain. They can describe simple equivalent circuits of transmission lines. They are able to solve problems with coupled transmission lines. They can present and discuss a self-chosen research topic. |
| *Skills* | Students can analyze and calculate the propagation of waves in simple circuits with transmission lines. They are able to analyze circuits in frequency domain and with the Smith chart. They can analyze equivalent circuits of transmission lines. They are able to solve problems including coupled transmission lines using the vectorial transmission line equations. They are able to give a talk to professionals. |
| **Personal Competence** | |
| *Social Competence* | Students can analyze and solve problems in small groups and discuss their solutions. They can compare the learned theory with experiments in the lecture and discuss it in small groups. They are able to present a research topic to professionals and discuss it with them. |
| *Autonomy* | The students can solve problems by their own and are able to acquire skills from the lecture and the literature. They are able to test their knowledge using computer animations. They can test their level of knowledge by answering short questions and tests during the lecture. They are able to relate their acquired knowledge to other lectures (e.g. Electrical Engineering I-III and Mathematics I-III). They can familiarize themselves with a research topic and can prepare a presentation. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |

| Studienleistung | Compulsory | Bonus | Form | Description |
|---|---|---|---|---|
| | Yes | None | Subject theoretical and practical work | |

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|---|---|
| **Examination** | Written exam |
| **Examination duration and scale** | 150 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Technomathematics: Core qualification: Elective Compulsory |

| **Course L0571: Research Seminar Electrical Engineering, Computer Science, Mathematics** | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des SD E |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | Seminar talk on a given subject |
| **Literature** | Themenabhängig / subject related |

| Course L0570: Transmission Line Theory | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Arne Jacob |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | - Wave propagation along transmission lines<br>- Transient behavior of transmission lines<br>- Transmission lines in steady state<br>- Impedance transformation and Smith chart<br>- Equivalent circuits<br>- Coupled transmission lines and symmetrical components |
| **Literature** | - Unger, H.-G., "Elektromagnetische Wellen auf Leitungen", Hüthig Verlag (1991) |

| Course L0572: Transmission Line Theory | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 2, Study Time in Lecture 28 |
| **Lecturer** | Prof. Arne Jacob |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

# Module M0734: Electrical Engineering Project Laboratory

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Electrical Engineering Project Laboratory (L0640) | Project-/problem-based Learning | 5 | 6 |

| | |
|---|---|
| **Module Responsible** | Prof. Christian Becker |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Electrical Engineering I, Electrical Engineering II |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to give a summary of the technical details of projects in the area of electrical engineering and illustrate respective relationships. They are capable of describing and communicating relevant problems and questions using appropriate technical language. They can explain the typical process of solving practical problems and present related results. |
| *Skills* | The students can transfer their fundamental knowledge on electrical engineering to the process of solving practical problems. They identify and overcome typical problems during the realization of projects in the context of electrical engineering. Students are able to develop, compare, and choose conceptual solutions for non-standardized problems. |
| **Personal Competence** | |
| *Social Competence* | Students are able to cooperate in small, mixed-subject groups in order to independently derive solutions to given problems in the context of electrical engineering. They are able to effectively present and explain their results alone or in groups in front of a qualified audience. Students have the ability to develop alternative approaches to an electrical engineering problem independently or in groups and discuss advantages as well as drawbacks. |
| *Autonomy* | Students are capable of independently solving electrical engineering problems using provided literature. They are able to fill gaps in as well as extent their knowledge using the literature and other sources provided by the supervisor. Furthermore, they can meaningfully extend given problems and pragmatically solve them by means of corresponding solutions and concepts. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Studienleistung** | None |
| **Examination** | Subject theoretical and practical work |

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|---|---|
| **Examination duration and scale** | based on task + presentation |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Technomathematics: Core qualification: Elective Compulsory |

| **Course L0640: Electrical Engineering Project Laboratory** | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 5 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Lecturer** | Prof. Christian Becker, Dozenten des SD E |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Topics and projects cover the entire field of applications of electrical engineering. Typically, the students will prototype functional units and self-contained systems, such as radar devices, networks of sensors, amateur radio transceiver, power electronics based inverters, discrete computers, or atomic force microscopes. Different projects are devised on a yearly basis. |
| **Literature** | Alle zur Durchführung der Projekte sinnvollen Quellen (Skripte, Fachbücher, Manuals, Datenblätter, Internetseiten). / All sources that are useful for completion of the projects (lecture notes, textbooks, manuals, data sheets, internet pages). |

# Module M0854: Mathematics IV

## Courses

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

| | |
|---|---|
| **Module Responsible** | Prof. Anusch Taraz |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mathematics 1 - III |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can name the basic concepts in Mathematics IV. They are able to explain them using appropriate examples.<br>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.<br>• They know proof strategies and can reproduce them. |
| *Skills* | • Students can model problems in Mathematics IV with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods.<br>• Students are able to discover and verify further logical connections between the concepts studied in the course.<br>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results. |
| **Personal Competence** | |
| *Social Competence* | • Students are able to work together in teams. They are capable to use mathematics as a common language.<br>• In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers. |
| *Autonomy* | • Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.<br>• Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems. |

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| **Workload in Hours** | Independent Study Time 68, Study Time in Lecture 112 |
| **Credit points** | 6 |
| **Studienleistung** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min (Complex Functions) + 60 min (Differential Equations 2) |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory<br>Computer Science: Specialisation Computational Mathematics: Elective Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Naval Architecture: Compulsory<br>Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory<br>Computational Science and Engineering: Specialisation Computer Science: Elective Compulsory<br>Computational Science and Engineering: Specialisation Mathematics & Engineering Science: Elective Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Compulsory<br>Mechatronics: Core qualification: Compulsory<br>Naval Architecture: Core qualification: Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory |

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

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

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

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

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

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

# Module M0569: Engineering Mechanics I

## Courses

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Engineering Mechanics I (L0187) | Lecture | 3 | 3 |
| Engineering Mechanics I (L0190) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Uwe Weltin |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Elementary knowledge in mathematics and physics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to describe fundamental connections, theories and methods to calculate forces in statically determined mounted systems of rigid bodies and fundamentals in elastostatics. |
| *Skills* | Students are able to apply theories and methods to calculate forces in statically determined mounted systems of rigid bodies and fundamentals of elastostatics. |
| **Personal Competence** | |
| *Social Competence* | Students are able to work goal-oriented in small mixed groups, learning and broadening teamwork abilities. |
| *Autonomy* | Students are able to solve individually exercises related to this lecture. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Studienleistung** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Elective Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Specialisation Mathematics & Engineering Science: Elective Compulsory<br>Logistics and Mobility: Core qualification: Compulsory<br>Process Engineering: Core qualification: Compulsory |

| Course L0187: Engineering Mechanics I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Uwe Weltin |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Methods to calculate forces in statically determined systems of rigid bodies<br>• Newton-Euler-Method<br>• Energy-Methods<br>Fundamentals of elasticity<br>• Forces and deformations in elastic systems |
| **Literature** | • Gross, D.; Hauger, W.; Schröder, J.; Wall, W.A.: Technische Mechanik 1: Statik, Springer Vieweg, 2013<br>• Gross, D.; Hauger, W.; Schröder, J.; Wall, W.A.: Technische Mechanik 2: Elastostatik, Springer Verlag, 2011<br>• Gross, D; Ehlers, W.; Wriggers, P.; Schröder, J.; Müller, R.: Formeln und Aufgaben zur Technischen Mechanik 1: Statik, Springer Vieweg, 2013<br>• Gross, D; Ehlers, W.; Wriggers, P.; Schröder, J.; Müller, R.: Formeln und Aufgaben zur Technischen Mechanik 2: Elastostatik, Springer Verlag, 2011<br>• Hibbeler, Russel C.: Technische Mechanik 1 Statik, Pearson Studium, 2012<br>• Hibbeler, Russel C.: Technische Mechanik 2 Festigkeitslehre, Pearson Studium, 2013<br>• Hauger, W.; Mannl, V.; Wall, W.A.; Werner, E.: Aufgaben zu Technische Mechanik 1-3: Statik, Elastostatik, Kinetik, Springer Verlag, 2011 |

| Course L0190: Engineering Mechanics I | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Uwe Weltin |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

# Module M0675: Introduction to Communications and Random Processes

## Courses

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Introduction to Communications and Random Processes (L0442) | Lecture | 3 | 4 |
| Introduction to Communications and Random Processes (L0443) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Gerhard Bauch |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Mathematics 1-3<br>• Signals and Systems<br>• Basic knowledge of probability theory |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students know and understand the fundamental building blocks of a communications system. They can describe and analyse the individual building blocks using knowledge of signal and system theory as well as the theory of stochastic processes. The are aware of the essential resources and evaluation criteria of information transmission and are able to design and evaluate a basic communications system. |
| *Skills* | The students are able to design and evaluate a basic communications system. In particular, they can estimate the required resources in terms of bandwidth and power. They are able to assess essential evaluation parameters of a basic communications system such as bandwidth efficiency or bit error rate and to decide for a suitable transmission method. |
| **Personal Competence** | |
| *Social Competence* | The students can jointly solve specific problems. |
| *Autonomy* | The students are able to acquire relevant information from appropriate literature sources. They can control their level of knowledge during the lecture period by solving tutorial problems, software tools, clicker system. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Studienleistung** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory |

| | |
|---|---|
| | Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Technomathematics: Core qualification: Elective Compulsory |

| Course L0442: Introduction to Communications and Random Processes | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Gerhard Bauch |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | • Fundamentals of random processes<br>• Introduction to communications engineering<br>• Quadrature amplitude modulation<br>• Description of radio frequency transmission in the equivalent complex baseband<br>• Transmission channels, channel models<br>• Analog digital conversion: Sampling, quantization, pulsecode modulation (PCM)<br>• Fundamentals of information theory, source coding, channel coding<br>• Digital baseband transmission: Pulse shaping, eye diagramm, 1. and 2. Nyquist condition, matched filter, detection, error probability<br>• Fundamentals of digital modulation |
| **Literature** | K. Kammeyer: Nachrichtenübertragung, Teubner<br>P.A. Höher: Grundlagen der digitalen Informationsübertragung, Teubner.<br>M. Bossert: Einführung in die Nachrichtentechnik, Oldenbourg.<br>J.G. Proakis, M. Salehi: Grundlagen der Kommunikationstechnik. Pearson Studium.<br>J.G. Proakis, M. Salehi: Digital Communications. McGraw-Hill.<br>S. Haykin: Communication Systems. Wiley<br>J.G. Proakis, M. Salehi: Communication Systems Engineering. Prentice-Hall.<br>J.G. Proakis, M. Salehi, G. Bauch, Contemporary Communication Systems. Cengage Learning. |

| Course L0443: Introduction to Communications and Random Processes | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Gerhard Bauch |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

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

## Courses

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

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

| | |
|---|---|
| **Examination** | Written exam |
| **Examination duration and scale** | 90-150 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Technomathematics: Core qualification: Elective Compulsory |

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

| Course L0183: Theoretical Electrical Engineering II: Time-Dependent Fields | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 2, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Schuster |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | - Theory and principal characteristics of quasistationary electromagnetic fields<br>- Electromagnetic induction and law of induction<br>- Skin effect and eddy currents<br>- Shielding of time variable magnetic fields<br>- Theory and principal characteristics of fully dynamic electromagnetic fields<br>- Wave equations and properties of planar waves<br>- Polarization and superposition of planar waves<br>- Reflection and refraction of planar waves at boundary surfaces<br>- Waveguide theory<br>- Rectangular waveguide, planar optical waveguide<br>- Elektrical and magnetical dipol radiation<br>- Simple arrays of antennas |
| **Literature** | - G. Lehner, "Elektromagnetische Feldtheorie: Für Ingenieure und Physiker", Springer (2010)<br>- H. Henke, "Elektromagnetische Felder: Theorie und Anwendung", Springer (2011)<br>- W. Nolting, "Grundkurs Theoretische Physik 3: Elektrodynamik", Springer (2011)<br>- D. Griffiths, "Introduction to Electrodynamics", Pearson (2012)<br>- J. Edminister, "Schaum's Outline of Electromagnetics", Mcgraw-Hill (2013)<br>- Richard Feynman, "Feynman Lectures on Physics: Volume 2", Basic Books (2011) |

# Module M0662: Numerical Mathematics I

## Courses

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

| | |
|---|---|
| **Module Responsible** | Prof. Sabine Le Borne |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Mathematik I + II for Engineering Students (german or english) **or** Analysis & Linear Algebra I + II for Technomathematicians<br>• basic MATLAB knowledge |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to<br>• name numerical methods for interpolation, integration, least squares problems, eigenvalue problems, nonlinear root finding problems and to explain their core ideas,<br>• repeat convergence statements for the numerical methods,<br>• explain aspects for the practical execution of numerical methods with respect to computational and storage complexitx. |
| *Skills* | Students are able to<br>• implement, apply and compare numerical methods using MATLAB,<br>• justify the convergence behaviour of numerical methods with respect to the problem and solution algorithm,<br>• select and execute a suitable solution approach for a given problem. |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>• work together in heterogeneously composed teams (i.e., teams from different study programs and background knowledge), explain theoretical foundations and support each other with practical aspects regarding the implementation of algorithms. |
| *Autonomy* | Students are capable<br>• to assess whether the supporting theoretical and practical excercises are better solved individually or in a team,<br>• to assess their individual progess and, if necessary, to ask questions and seek help. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Studienleistung** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| | General Engineering Science (German program): Specialisation Computer Science: |

| | |
|---|---|
| **Assignment for the Following Curricula** | Compulsory<br>General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory<br>General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Computer Science: Specialisation Computational Mathematics: Elective Compulsory<br>Electrical Engineering: Core qualification: Elective Compulsory<br>General Engineering Science (English program): Specialisation Computer Science: Compulsory<br>General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Computer Science: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory |

| Course L0417: Numerical Mathematics I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Sabine Le Borne, Dr. Patricio Farrell |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | 1. Error analysis: Number representation, error types, conditioning and stability<br>2. Interpolation: polynomial and spline interpolation<br>3. Numerical integration and differentiation: order, Newton-Cotes formula, error estimates, Gaussian quadrature, adaptive quadrature, difference formulas<br>4. Linear systems: LU and Cholesky factorization, matrix norms, conditioning<br>5. Linear least squares problems: normal equations, Gram.Schmidt and Householder orthogonalization, singular value decomposition, regularization<br>6. Eigenvalue problems: power iteration, inverse iteration, QR algorithm<br>7. Nonlinear systems of equations: Fixed point iteration, root-finding algorithms for real-valued functions, Newton and Quasi-Newton methods for systems |
| **Literature** | • Stoer/Bulirsch: Numerische Mathematik 1, Springer<br>• Dahmen, Reusken: Numerik für Ingenieure und Naturwissenschaftler, Springer |

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

| | |
|---|---|
| **Module Responsible** | Prof. Hoc Khiem Trieu |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Atomic model and quantum theory, electrical currents in solid state materials, basics in solid-state physics<br><br>Successful participation of Physics for Engineers and Materials in Electrical Engineering or courses with equivalent contents |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able<br>• to represent the basics of semiconductor physics,<br>• to explain the operating principle of important semiconductor devices,<br>• to outline device characteristics and equivalent circuits as well as to explain their derivation and<br>• to discuss the limitation of device models. |
| *Skills* | Students are capable<br>• to apply devices in basic circuits,<br>• to realize the physical context and to solve complex problems by oneself |
| **Personal Competence** | |
| *Social Competence* | Students are able to prepare and perform their lab experiments in team work as well as to present and discuss the results in front of audience. |
| *Autonomy* | Students are capable to acquire knowledge based on literature in order to prepare their experiments. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |

| Compulsory Bonus | Form | Description |
|---|---|---|
| | | Studierenden erarbeiten in Kleingruppen Wissen zu einem bestimmten Thema, demonstrieren |

| | | | | |
|---|---|---|---|---|
| **Studienleistung** | Yes | 10 % | Subject theoretical and practical work | dieses in Form eines Versuches mit Präsentation und Diskussion. Darüber hinaus betreut jede Gruppe eine Übungsaufgabe, die inhaltlich zu dem jeweiligen Versuch gehört. |
| **Examination** | Written exam | | | |
| **Examination duration and scale** | 120 min | | | |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>Computational Science and Engineering: Specialisation Mathematics & Engineering Science: Elective Compulsory | | | |

| Course L0720: Electronic Devices | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Hoc Khiem Trieu |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Uniformly doped semiconductor (semiconductor, crystal structure, energy band diagram, effective mass, density of state, probability of occupancy, mass action law, generation and recombination processes, generation and recombination lifetime, carrier transport mechanisms: drift current, diffusion current; equilibriums in semiconductor, semiconductor equations)<br>• 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)<br>• 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)<br>• Unipolar devices (surface effects: surface states, work function, energy band diagram; metal-semiconductor junctions: Schottky contact, current-voltage characteristics, ohmic contact; junction field effect transistor: operating principle, current-voltage characteristics, small-signal model, breakdown characteristics; MESFET: operating principle, depletion mode and enhancement mode MESFET; MIS structure: accumulation, depletion, inversion, strong inversion, flatband voltage, oxide charges, threshold voltage, capacitance voltage characteristics; MOSFET: basic structure, principle of operation, current voltage characteristics, frequency response, subthreshold behaviour, threshold voltage, device scaling; CMOS) |
| **Literature** | S.M. Sze: Semiconductor devices, Physics and Technology, John Wiley & Sons (1985)F. Thuselt: Physik der Halbleiterbauelemente, Springer (2011)<br><br>T. Thille, D. Schmitt-Landsiedel: Mikroelektronik, Halbleiterbauelemente und deren Anwendung in elektronischen Schaltungen, Springer (2004)<br><br>B.L. Anderson, R.L. Anderson: Fundamentals of Semiconductor Devices, McGraw-Hill (2005)<br><br>D.A. Neamen: Semiconductor Physics and Devices, McGraw-Hill (2011)<br><br>M. Shur: Introduction to Electronic Devices, John Wiley & Sons (1996)<br><br>S.M. Sze: Physics of semiconductor devices, John Wiley & Sons (2007)<br><br>H. Schaumburg: Halbleiter, B.G. Teubner (1991)<br><br>A. Möschwitzer: Grundlagen der Halbleiter-&Mikroelektronik, Bd1 Elektronische Halbleiterbauelemente, Carl Hanser (1992)<br><br>H.-G. Unger, W. Schultz, G. Weinhausen: Elektronische Bauelemente und Netzwerke I, Physikalische Grundlagen der Halbleiterbauelemente, Vieweg (1985) |

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

# Module M0834: Computernetworks and Internet Security

## Courses

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

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

| Course L1098: Computer Networks and Internet Security | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 5 |
| **Workload in Hours** | Independent Study Time 108, Study Time in Lecture 42 |
| **Lecturer** | Prof. Andreas Timm-Giel, Prof. Dieter Gollmann |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | In this class an introduction to computer networks with focus on the Internet and its security is given. Basic functionality of complex protocols are introduced. Students learn to understand these and identify common principles. In the exercises these basic principles and an introduction to performance modelling are addressed using computing tasks and (virtual) labs.<br><br>In the second part of the lecture an introduction to Internet security is given.<br><br>This class comprises:<br><br>• Application layer protocols (HTTP, FTP, DNS)<br>• Transport layer protocols (TCP, UDP)<br>• Network Layer (Internet Protocol, routing in the Internet)<br>• Data link layer with media access at the example of Ethernet<br>• Multimedia applications in the Internet<br>• Network management<br>• Internet security: IPSec<br>• Internet security: Firewalls |
| **Literature** | • Kurose, Ross, Computer Networking - A Top-Down Approach, 6th Edition, Addison-Wesley<br>• Kurose, Ross, Computernetzwerke - Der Top-Down-Ansatz, Pearson Studium; Auflage: 6. Auflage<br>• W. Stallings: Cryptography and Network Security: Principles and Practice, 6th edition<br><br>Further literature is announced at the beginning of the lecture. |

| Course L1099: Computer Networks and Internet Security | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Andreas Timm-Giel, Prof. Dieter Gollmann |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

# Module M0833: Introduction to Control Systems

## Courses

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

| | |
|---|---|
| **Module Responsible** | Prof. Herbert Werner |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Representation of signals and systems in time and frequency domain, Laplace transform |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can represent dynamic system behavior in time and frequency domain, and can in particular explain properties of first and second order systems<br>• They can explain the dynamics of simple control loops and interpret dynamic properties in terms of frequency response and root locus<br>• They can explain the Nyquist stability criterion and the stability margins derived from it.<br>• They can explain the role of the phase margin in analysis and synthesis of control loops<br>• They can explain the way a PID controller affects a control loop in terms of its frequency response<br>• They can explain issues arising when controllers designed in continuous time domain are implemented digitally |
| *Skills* | • Students can transform models of linear dynamic systems from time to frequency domain and vice versa<br>• They can simulate and assess the behavior of systems and control loops<br>• They can design PID controllers with the help of heuristic (Ziegler-Nichols) tuning rules<br>• They can analyze and synthesize simple control loops with the help of root locus and frequency response techniques<br>• They can calculate discrete-time approximations of controllers designed in continuous-time and use it for digital implementation<br>• They can use standard software tools (Matlab Control Toolbox, Simulink) for carrying out these tasks |
| **Personal Competence** | |
| *Social Competence* | Students can work in small groups to jointly solve technical problems, and experimentally validate their controller designs |
| *Autonomy* | Students can obtain information from provided sources (lecture notes, software documentation, experiment guides) and use it when solving given problems.<br><br>They can assess their knowledge in weekly on-line tests and thereby control their learning progress. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |

| | |
|---|---|
| **Credit points** | 6 |
| **Studienleistung** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Core qualification: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Civil Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>Bioprocess Engineering: Core qualification: Compulsory<br>Computer Science: Specialisation Computational Mathematics: Elective Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Core qualification: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Computer Science: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Civil Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical |

| | |
|---|---|
| | Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Logistics and Mobility: Specialisation Engineering Science: Elective Compulsory<br>Mechanical Engineering: Core qualification: Compulsory<br>Mechatronics: Core qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory<br>Process Engineering: Core qualification: Compulsory |

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

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

# Module M1235: Electrical Power Systems I

## Courses

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Electrical Power Systems I (L1670) | Lecture | 3 | 4 |
| Electrical Power Systems I (L1671) | Recitation Section (large) | 2 | 2 |

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

| Course L1670: Electrical Power Systems I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Christian Becker |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • fundamentals and current development trends in electric power engineering<br>• tasks and history of electric power systems<br>• symmetric three-phase systems<br>• fundamentals and modelling of eletric power systems<br>  ◦ lines<br>  ◦ transformers<br>  ◦ synchronous machines<br>  ◦ induction machines<br>  ◦ loads and compensation<br>  ◦ grid structures and substations<br>• fundamentals of energy conversion<br>  ◦ electro-mechanical energy conversion<br>  ◦ thermodynamics<br>  ◦ power station technology<br>  ◦ renewable energy conversion systems<br>• steady-state network calculation<br>  ◦ network modelling<br>  ◦ load flow calculation<br>  ◦ (n-1)-criterion<br>• symmetric failure calculations, short-circuit power<br>• control in networks and power stations<br>• grid protection<br>• grid planning<br>• power economy fundamentals |
| **Literature** | K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013<br><br>A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017<br><br>R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008 |

| Course L1671: Electrical Power Systems I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Becker |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • fundamentals and current development trends in electric power engineering<br>• tasks and history of electric power systems<br>• symmetric three-phase systems<br>• fundamentals and modelling of eletric power systems<br>  ◦ lines<br>  ◦ transformers<br>  ◦ synchronous machines<br>  ◦ induction machines<br>  ◦ loads and compensation<br>  ◦ grid structures and substations<br>• fundamentals of energy conversion<br>  ◦ electro-mechanical energy conversion<br>  ◦ thermodynamics<br>  ◦ power station technology<br>  ◦ renewable energy conversion systems<br>• steady-state network calculation<br>  ◦ network modelling<br>  ◦ load flow calculation<br>  ◦ (n-1)-criterion<br>• symmetric failure calculations, short-circuit power<br>• control in networks and power stations<br>• grid protection<br>• grid planning<br>• power economy fundamentals |
| **Literature** | K. Heuck, K.-D. Dettmann, D. Schulz: "Elektrische Energieversorgung", Vieweg + Teubner, 9. Auflage, 2013<br><br>A. J. Schwab: "Elektroenergiesysteme", Springer, 5. Auflage, 2017<br><br>R. Flosdorff: "Elektrische Energieverteilung" Vieweg + Teubner, 9. Auflage, 2008 |

# Module M1242: Quantum Mechanics for Engineers

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Quantum Mechanics for Engineers (L1686) | Lecture | 2 | 3 |
| Quantum Mechanics for Engineers (L1688) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Wolfgang Hansen |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Knowledge in physics, particularly in optics and wave phenomena;<br>• knowledge in mathematics, particularly linear algebra, vector calculus, complex numbers and Fourier expansion |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are able to describe and explain basic terms and principles of quantum mechanics. They can distinguish commons and differences to classical physics and know, in which situations quantum mechanical phenomena may be expected. |
| *Skills* | The students get the ability to apply concepts and methods of quantum mechanics to simple problems and systems. Vice versa, they are also able to comprehend requirements and principles of quantum mechanical devices. |
| **Personal Competence** | |
| *Social Competence* | The students discuss contents of the lectures and present solutions to simple quantum mechanical problems in small groups during the exercises. |
| *Autonomy* | The students are able to independently find answers to simple questions on quantum mechanical systems. The students are able to independently comprehend literature to more complex subjects with quantum mechanical background. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |

| **Studienleistung** | **Compulsory** | **Bonus** | **Form** | **Description** |
|---|---|---|---|---|
| | No | None | Written elaboration | |

| | |
|---|---|
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | Electrical Engineering: Core qualification: Elective Compulsory<br>Computational Science and Engineering: Specialisation Computer Science: Elective Compulsory |

| Course L1686: Quantum Mechanics for Engineers | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Wolfgang Hansen |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | This lecture introduces into fundamental concepts, methods, and definitions in quantum mechanics, which are needed in modern material and device science. Applications will be discussed using examples in the field of electronic and optical devices.<br><br>Central topics are:<br><br>Schrödinger equation, wave function, operators, eigenstates, eigenvalues, quantum wells, harmonic oscillator, tunnel processes, resonant tunnel diode, band structure, density of states, quantum statistics, Zener-diode, stationary perturbation calculation with the quantum-confined Stark effect as an example, Fermi's golden rule and transition matrix elements, heterostructure laser, quantum cascade laser, many-particle physics, molecules and exchange interaction, quantum bits and quantum cryptography. |
| **Literature** | • David J. Griffiths: "Quantenmechanik, eine Einführung", Pearson (2012), ISBN 978-3-8632-6514-4.<br>• David K. Ferry: "Quantum Mechanics", IOP Publishing (1995), ISBN 0-7503-0327-1 (hbk) bzw. 0-7503-0328-X (pbk).<br>• M. Jaros: " Physics and Applications of Semiconductor Microstructures ", Clarendon Press (1989), ISBN: 0-19-851994-X bzw. 0-19-853927-4 (Pbk).<br>• Randy Harris, "Moderne Physik Lehr- und Übungsbuch", 2. aktualisierte Auflage, Kapitel 3-10, Pearson (2013), ISBN 978-3-86894-115-9.<br>• Michael A Nielsen and Isaac L. Chuang: "Quantum Computation and Quantum Informatioin", 10. Auflage, Cambridge University Press (2011), ISBN: 1107002176 9781107002173.<br>• Hiroyuki Sagawa and Nobuaki Yoshida: "Fundamentals of Quantum Information", World Scientific Publishing (2010), ISBN-13: 978-9814324236. |

| Course L1688: Quantum Mechanics for Engineers | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Wolfgang Hansen |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

# Module M0570: Engineering Mechanics II

## Courses

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Engineering Mechanics II (L0191) | Lecture | 3 | 3 |
| Engineering Mechanics II (L0192) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Uwe Weltin |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Technical Mechnics I |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to describe connections, theories and methods to calculate forces and motions of rigid bodies in 3D. |
| *Skills* | Students are able to apply theories and method to calculate forces and motions of rigid bodies in 3D. |
| **Personal Competence** | |
| *Social Competence* | Students are able to work goal-oriented in small mixed groups, learning and broadening teamwork abilities. |
| *Autonomy* | Students are able to solve individually exercises related to this lecture with instructional direction. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Studienleistung** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core qualification: Compulsory<br>Electrical Engineering: Core qualification: Elective Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Logistics and Mobility: Core qualification: Compulsory<br>Process Engineering: Core qualification: Compulsory |

| Course L0191: Engineering Mechanics II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Uwe Weltin |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Method for calculation of forces and motion of rigid bodies in 3D<br>• Newton-Euler-Method<br>• Energy methods |
| **Literature** | • Gross, D.; Hauger, W.; Schröder, J.; Wall, W.A.: Technische Mechanik 2: Elastostatik, Springer Verlag, 2011<br>• Gross, D.; Hauger, W.; Schröder, J.; Wall, W.A.: Technische Mechanik 3: Kinetik, Springer Vieweg, 2012<br>• Gross, D; Ehlers, W.; Wriggers, P.; Schröder, J.; Müller, R.: Formeln und Aufgaben zur Technischen Mechanik 2: Elastostatik, Springer Verlag, 2011<br>• Gross, D; Ehlers, W.; Wriggers, P.; Schröder, J.; Müller, R.: Formeln und Aufgaben zur Technischen Mechanik 3: Kinetik, Springer Vieweg, 2012<br>• Hibbeler, Russel C.: Technische Mechanik 2 Festigkeitslehre, Pearson Studium, 2013<br>• Hibbeler, Russel C.: Technische Mechanik 3 Dynamik, Pearson Studium, 2012<br>• Hauger, W.; Mannl, V.; Wall, W.A.; Werner, E.: Aufgaben zu Technische Mechanik 1-3: Statik, Elastostatik, Kinetik, Springer Verlag, 2011 |

| Course L0192: Engineering Mechanics II | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Uwe Weltin |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

# Module M0610: Electrical Machines

## Courses

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

| | |
|---|---|
| **Module Responsible** | Prof. Thanh Trung Do |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of mathematics, in particular complexe numbers, integrals, differentials<br>Basics of electrical engineering and mechanical engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can to draw and explain the basic principles of electric and magnetic fields.<br>They can describe the function of the standard types of electric machines and present the corresponding equations and characteristic curves. For typically used drives they can explain the major parameters of the energy efficiency of the whole system from the power grid to the driven engine. |
| *Skills* | Students arw able to calculate two-dimensional electric and magnetic fields in particular ferromagnetic circuits with air gap. For this they apply the usual methods of the design auf electric machines.<br>They can calulate the operational performance of electric machines from their given characteristic data and selected quantities and characteristic curves. They apply the usual equivalent circuits and graphical methods. |
| **Personal Competence** | |
| *Social Competence* | none |
| *Autonomy* | Students are able independently to calculate electric and magnatic fields for applications. They are able to analyse independently the operational performance of electric machines from the charactersitic data and theycan calculate thereof selected quantities and characteristic curves. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Studienleistung** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 Minuten |
| | General Engineering Science (German program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Mechanical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory |

| | |
|---|---|
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering: Elective Compulsory<br>Electrical Engineering: Core qualification: Elective Compulsory<br>Energy and Environmental Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Mechanical Engineering: Elective Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Energy and Enviromental Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Elective Compulsory<br>Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory<br>Logistics and Mobility: Specialisation Engineering Science: Elective Compulsory<br>Mechanical Engineering: Core qualification: Elective Compulsory<br>Mechatronics: Core qualification: Compulsory |

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

| Course L0294: Electrical Machines | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thanh Trung Do, Weitere Mitarbeiter |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Exercises to the application of electric and magnetic fields.<br><br>Excercises to the operational performance of eletric machines. |
| **Literature** | Hermann Linse, Roland Fischer: "Elektrotechnik für Maschinenbauer", Vieweg-Verlag; Signatur der Bibliothek der TUHH: ETB 313<br><br>Ralf Kories, Heinz Schmitt-Walter: "Taschenbuch der Elektrotechnik"; Verlag Harri Deutsch; Signatur der Bibliothek der TUHH: ETB 122<br><br>"Grundlagen der Elektrotechnik" - anderer Autoren<br><br>Fachbücher "Elektrische Maschinen" |

# Module M0634: Introduction into Medical Technology and Systems

## Courses

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

| | |
|---|---|
| **Module Responsible** | Prof. Alexander Schlaefer |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | principles of math (algebra, analysis/calculus)<br>principles of stochastics<br>principles of programming, R/Matlab |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can explain principles of medical technology, including imaging systems, computer aided surgery, and medical information systems. They are able to give an overview of regulatory affairs and standards in medical technology. |
| *Skills* | The students are able to evaluate systems and medical devices in the context of clinical applications. |
| **Personal Competence** | |
| *Social Competence* | The students describe a problem in medical technology as a project, and define tasks that are solved in a joint effort. |
| *Autonomy* | The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |

**Studienleistung**

| Compulsory | Bonus | Form | Description |
|---|---|---|---|
| Yes | 10 % | Written elaboration | |
| Yes | 10 % | Presentation | |

| | |
|---|---|
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory<br>Electrical Engineering: Core qualification: Elective Compulsory<br>General Engineering Science (English program): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>Computational Science and Engineering: Specialisation Engineering Sciences: Elective Compulsory<br>Computational Science and Engineering: Specialisation Computer Science: Elective |

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| | Compulsory<br>Computational Science and Engineering: Specialisation Mathematics & Engineering Science: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| **Course L0342: Introduction into Medical Technology and Systems** | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Alexander Schlaefer |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | - imaging systems<br>- computer aided surgery<br>- medical sensor systems<br>- medical information systems<br>- regulatory affairs<br>- standard in medical technology<br>The students will work in groups to apply the methods introduced during the lecture using problem based learning. |
| **Literature** | Wird in der Veranstaltung bekannt gegeben. |

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

| Course L1876: Introduction into Medical Technology and Systems | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Alexander Schlaefer |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | - imaging systems<br>- computer aided surgery<br>- medical sensor systems<br>- medical information systems<br>- regulatory affairs<br>- standard in medical technology<br>The students will work in groups to apply the methods introduced during the lecture using problem based learning. |
| **Literature** | Wird in der Veranstaltung bekannt gegeben. |

# Module M0777: Semiconductor Circuit Design

## Courses

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

| | |
|---|---|
| **Module Responsible** | Prof. Matthias Kuhl |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals of electrical engineering<br>Basics of physics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students are able to explain the functionality of different MOS devices in electronic circuits.<br>• Students know the fundamental digital logic circuits and can discuss their advantages and disadvantages.<br>• Students have solid knowledge about memory circuits and can explain their functionality and specifications.<br>• Students are able to explain how analog circuits functions and where they are applied.<br>• Students know the appropriate fields for the use of bipolar transistors. |
| *Skills* | • Students can calculate the specifications of different MOS devices and can define the parameters of electronic circuits.<br>• Students are able to develop different logic circuits and can design different types of logic circuits.<br>• Students can use MOS devices, operational amplifiers and bipolar transistors for specific applications. |
| **Personal Competence** | |
| *Social Competence* | • Students are able work efficiently in heterogeneous teams.<br>• Students working together in small groups can solve problems and answer professional questions. |
| *Autonomy* | • Students are able to assess their level of knowledge. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Studienleistung** | None |
| **Examination** | Written exam |

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|---|---|
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>Electrical Engineering: Core qualification: Compulsory<br>General Engineering Science (English program): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>Computational Science and Engineering: Specialisation Mathematics & Engineering Science: Elective Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Compulsory<br>Mechatronics: Core qualification: Compulsory<br>Technomathematics: Core qualification: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| Course L0763: Semiconductor Circuit Design | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Matthias Kuhl |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Basic circuits with MOS transistors for logic gates and amplifiers<br>• Typical applications for analog and digital circuits<br>• Realization of logical functions<br>• Memory circuits<br>• Scaling-down of CMOS circuits and further perfomance improvements<br>• Operational amplifiers and their applications<br>• Basic circuits with bipolar transistors<br>• Design of exemplary circuits<br>• Electrical behavoir of BiCMOS circuits<br><br>From the summer semester 2017 onwards, students have the possibility to get a bonus of 0,3 to 0,7 for improving the (passed) exam by writing a test on either the 16.05., 13.06. or the 04.07.2017. The test includes 10 questions (time limit: 20 min.). |
| **Literature** | R. J. Baker, CMOS - Circuit Design, Layout and Simulation, J. Wiley & Sons Inc., 3. Auflage, 2011, ISBN: 047170055S<br><br>H.-G. Wagemann und T. Schönauer, Silizium-Planartechnologie, Grundprozesse, Physik und Bauelemente, Teubner-Verlag, 2003, ISBN 3519004674<br><br>K. Hoffmann, Systemintegration, Oldenbourg-Verlag, 2. Aufl. 2006, ISBN: 3486578944<br><br>U. Tietze und Ch. Schenk, E. Gamm, Halbleiterschaltungstechnik, Springer Verlag, 14. Auflage, 2012, ISBN 3540428496<br><br>H. Göbel, Einführung in die Halbleiter-Schaltungstechnik, Berlin, Heidelberg Springer-Verlag Berlin Heidelberg, 2011, ISBN: 9783642208874 ISBN: 9783642208867<br><br>URL: http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10499499<br><br>URL: http://dx.doi.org/10.1007/978-3-642-20887-4<br><br>URL: http://ebooks.ciando.com/book/index.cfm/bok_id/319955<br><br>URL: http://www.ciando.com/img/bo |

| Course L0864: Semiconductor Circuit Design | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Matthias Kuhl |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Basic circuits with MOS transistors for logic gates and amplifiers<br>• Typical applications for analog and digital circuits<br>• Realization of logical functions<br>• Memory circuits<br>• Scaling-down of CMOS circuits and further perfomance improvements<br>• Operational amplifiers and their applications<br>• Basic circuits with bipolar transistors<br>• Design of exemplary circuits<br>• Electrical behavoir of BiCMOS circuits |
| **Literature** | R. J. Baker, CMOS - Circuit Design, Layout and Simulation, J. Wiley & Sons Inc., 3. Auflage, 2011, ISBN: 047170055S<br><br>H.-G. Wagemann und T. Schönauer, Silizium-Planartechnologie, Grundprozesse, Physik und Bauelemente, Teubner-Verlag, 2003, ISBN 3519004674<br><br>K. Hoffmann, Systemintegration, Oldenbourg-Verlag, 2. Aufl. 2006, ISBN: 3486578944<br><br>U. Tietze und Ch. Schenk, E. Gamm, Halbleiterschaltungstechnik, Springer Verlag, 14. Auflage, 2012, ISBN 3540428496<br><br>H. Göbel, Einführung in die Halbleiter-Schaltungstechnik, Berlin, Heidelberg Springer-Verlag Berlin Heidelberg, 2011, ISBN: 9783642208874 ISBN: 9783642208867<br><br>URL: http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10499499<br><br>URL: http://dx.doi.org/10.1007/978-3-642-20887-4<br><br>URL: http://ebooks.ciando.com/book/index.cfm/bok_id/319955<br><br>URL: http://www.ciando.com/img/bo |

# Module M0803: Embedded Systems

## Courses

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Embedded Systems (L0805) | Lecture | 3 | 4 |
| Embedded Systems (L0806) | Recitation Section (small) | 1 | 2 |

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|---|---|
| **Module Responsible** | Prof. Heiko Falk |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Computer Engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Embedded systems can be defined as information processing systems embedded into enclosing products. This course teaches the foundations of such systems. In particular, it deals with an introduction into these systems (notions, common characteristics) and their specification languages (models of computation, hierarchical automata, specification of distributed systems, task graphs, specification of real-time applications, translations between different models).<br>Another part covers the hardware of embedded systems: Sonsors, A/D and D/A converters, real-time capable communication hardware, embedded processors, memories, energy dissipation, reconfigurable logic and actuators. The course also features an introduction into real-time operating systems, middleware and real-time scheduling. Finally, the implementation of embedded systems using hardware/software co-design (hardware/software partitioning, high-level transformations of specifications, energy-efficient realizations, compilers for embedded processors) is covered. |
| *Skills* | After having attended the course, students shall be able to realize simple embedded systems. The students shall realize which relevant parts of technological competences to use in order to obtain a functional embedded systems. In particular, they shall be able to compare different models of computations and feasible techniques for system-level design. They shall be able to judge in which areas of embedded system design specific risks exist. |
| **Personal Competence** | |
| *Social Competence* | Students are able to solve similar problems alone or in a group and to present the results accordingly. |
| *Autonomy* | Students are able to acquire new knowledge from specific literature and to associate this knowledge with other classes. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Studienleistung** | **Compulsory** Yes; **Bonus** 10 %; **Form** Subject theoretical and practical work; **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes, contents of course and labs |
| | General Engineering Science (German program, 7 semester): Specialisation Computer Science: Elective Compulsory<br>Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory |

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|---|---|
| **Assignment for the Following Curricula** | Electrical Engineering: Core qualification: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Avionic and Embedded Systems: Elective Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Computer Science: Elective Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Computational Science and Engineering: Core qualification: Compulsory<br>Mechatronics: Specialisation System Design: Elective Compulsory<br>Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory<br>Microelectronics and Microsystems: Specialisation Embedded Systems: Elective Compulsory |

| **Course L0805: Embedded Systems** | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Heiko Falk |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Introduction<br>• Specifications and Modeling<br>• Embedded/Cyber-Physical Systems Hardware<br>• System Software<br>• Evaluation and Validation<br>• Mapping of Applications to Execution Platforms<br>• Optimization |
| **Literature** | • Peter Marwedel. Embedded System Design - Embedded Systems Foundations of Cyber-Physical Systems. 2nd Edition, Springer, 2012., Springer, 2012. |

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

# Thesis

## Module M-001: Bachelor Thesis

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |

| | |
|---|---|
| **Module Responsible** | Professoren der TUHH |
| **Admission Requirements** | • According to General Regulations §21 (1):<br><br>At least 126 ECTS credit points have to be achieved in study programme. The examinations board decides on exceptions. |
| **Recommended Previous Knowledge** | |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • The students can select, outline and, if need be, critically discuss the most important scientific fundamentals of their course of study (facts, theories, and methods).<br>• 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.<br>• The students are able to outline the state of research on a selected issue in their subject area. |
| *Skills* | • The students can make targeted use of the basic knowledge of their subject that they have acquired in their studies to solve subject-related problems.<br>• 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.<br>• The students can take up a critical position on the findings of their own research work from a specialized perspective. |
| **Personal Competence** | |
| *Social Competence* | • Both in writing and orally the students can outline a scientific issue for an expert audience accurately, understandably and in a structured way.<br>• The students can deal with issues in an expert discussion and answer them in a manner that is appropriate to the addressees. In doing so they can uphold their own assessments and viewpoints convincingly. |
| *Autonomy* | • The students are capable of structuring an extensive work process in terms of time and of dealing with an issue within a specified time frame.<br>• The students are able to identify, open up, and connect knowledge and material necessary for working on a scientific problem.<br>• The students can apply the essential techniques of scientific work to research of their own. |

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|---|---|
| **Workload in Hours** | Independent Study Time 360, Study Time in Lecture 0 |
| **Credit points** | 12 |
| **Studienleistung** | None |
| **Examination** | Thesis |
| **Examination duration and scale** | According to General Regulations |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Thesis: Compulsory<br>General Engineering Science (German program, 7 semester): Thesis: Compulsory<br>Civil- and Environmental Engineering: Thesis: Compulsory<br>Bioprocess Engineering: Thesis: Compulsory<br>Computer Science: Thesis: Compulsory<br>Electrical Engineering: Thesis: Compulsory<br>Energy and Environmental Engineering: Thesis: Compulsory<br>General Engineering Science (English program): Thesis: Compulsory<br>General Engineering Science (English program, 7 semester): Thesis: Compulsory<br>Computational Science and Engineering: Thesis: Compulsory<br>Computational Science and Engineering: Thesis: Compulsory<br>Logistics and Mobility: Thesis: Compulsory<br>Mechanical Engineering: Thesis: Compulsory<br>Mechatronics: Thesis: Compulsory<br>Naval Architecture: Thesis: Compulsory<br>Technomathematics: Thesis: Compulsory<br>xx: Thesis: Compulsory<br>Process Engineering: Thesis: Compulsory |