TUHH
Hamburg
University of
Technology

# Module Manual

Bachelor of Science (B.Sc.)

# Mechanical Engineering

Cohort: Winter Term 2023

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# Program description

## Content

Today one can find mechanical engineering in practically all industrially made goods of everyday life like cars, electronic devices or tools. Mechanical engineering incorporates technologies and develops market ready products from basic developments. Accordingly the field of activity of mechanical engineers is wide: Planning and calculation of plants, devices and machines, selection and development of materials, design of mechanical devices taking into account economic manufacturing and planning of production plants are examples. Developments in micro system technology, mechatronics and microelectronics extended the field of work during the last years. In addition, subjects outside the field of technology become more and more important for engineers.

The aim of the mechanical engineering programs at TUHH (bachelor and master) is to successfully prepare young people for their career start in this wide and always varying field. Mechanical engineers work in industry, medium-sized companies, public facilities, colleges and engineer's offices. Their activities can include various areas like research, development, production, project management, distribution, marketing and quality assurance.

The variety of applications within this occupation demands a high degree of specialization. Consequently, the professional training of mechanical engineers must balance the wide range of knowledge to be acquired (to offer diverse applications in the future) and the profoundness of training (for up-to-date technical competences). In the course of the consecutive bachelor's and master's program in mechanical engineering at the TUHH, the wide range of knowledge is taught mostly during the bachelor's program while specific skills are developed during the master's program. In any case, a profound understanding of the basics as well as a proficiency in common methods are part of the education. The course of study leading to the "Bachelor of Science" degree in mechanical engineering is designed with this aspiration. The fundamentals necessary to solve tasks in mechanical engineering are taught. Additionally, skills in an area of focus are taught during the bachelor's degree course. The degree qualifies students to work professionally in typical fields of mechanical engineering:

- Product development and production (production technologies, materials, lightweight design),
- Aircraft systems engineering (aircraft systems, simulation product development),
- Energy systems (thermal power plants, piston engines),
- Mechatronics (simulation, semiconductor technology),
- Biomechanics (medicine, implants),
- Materials in engineering sciences (materials sciences, structural materials)

In reality, the transitions between the individual fields of mechanical engineering are blurred. The listed fields of application can be further pursued on in one of the master's programs in mechanical engineering.

In addition to the technical basics, an education in non-technical areas such as business administration, patent law, humanities as well as law and philosophy is pursued that fulfills the demands made on modern day engineers.

## Career prospects

The courses' graduates are able to work responsibly and proficiently as mechanical engineers. According to the laws of the states of the Federal Republic of Germany, they may use the professional title engineer. Possible employers are for example manufacturing companies in the mechanical engineering sector as well as engineering and planning offices. The degree allows for further studies in a masters' program, e.g. the consecutive programs corresponding to the areas of focus.

## Learning target

The education objective of this bachelor's program is to develop the skills to select and combine basic methods and techniques to carry out technical tasks in the field of mechanical engineering and more specifically in the chosen area of focus.

**Knowledge**

- The students are able to name and describe the mathematical and scientific fundamentals and methods of the engineering sciences.
- The students are able to explain the fundamentals and methods of mechanical engineering and to give a summary of their field of studies.
- The students are able to explain in detail the fundamentals, methods, and areas of application of the individual areas of mechanical engineering.
- The students are able to reflect the fundamentals and methods of mechanical engineering and to give a summary of the relevant social, ethical, ecological, and economical boundary conditions of their field of studies.
- Knowledge in the areas of focus:
    - Biomechanics: The students are able to describe different types of implants and large-scale equipment for diagnosis and therapy and to explain their workings.
    - Energy Systems: The students are able to explain technologies for the conversion, distribution, and use of energy.
    - Aircraft Systems Engineering: The Students are able to explain methods of systems engineering in relation to aircraft design and production.
    - Materials in Engineering Sciences: The students are able to explain characteristics of engineering materials, particularly of metals, ceramics, and structural materials.
    - Mechatronics: The students are able to explain mechatronic systems and their function from the perspectives of mechanical and electrical engineering.
    - Product Development and Production: The Students are able to explain all steps of the product development process.
    - Theoretical Mechanical Engineering: The students are able to describe the problems of mechanical engineering based on theoretical fundamentals.

**Skills**

- The students are able to apply their knowledge about mathematical and scientific fundamentals and methods of engineering to simple theoretical and practical problems and to develop solutions.
- The Students are able to map typical detailed theoretical as well as practical mechanical engineering problems (e.g. dimensioning of machine parts such as shafts and bearings, calculation of energy flows) to their knowledge of fundamentals. They are able to analyze these problems methodically and based on fundamentals and to find and implement appropriate solution methods. They are able to document the chosen solution method adequately in writing.
- The students are able to map practical, rather general mechanical engineering problems (e.g. design of devices) to sub-problems from their or other relevant fields, to analyze them methodically and based on fundamentals and to find and implement appropriate solution methods. They are able to present their solution to an audience in a clearly structured manner.
- The students are able to handle practical engineering problems from research independently by applying appropriate methods, to document their chosen approach and to present it in front of an expert audience.

- skills in the area of focus:
  - Biomechanics: The students are able to analyze medical equipment and implants by applying scientific methods
  - Energy Systems: The Students are able to analyze processes such as combustion systems or recuperators by applying scientific methods.
  - Aircraft System Engineering: The students are able to apply the standard methods of aircraft design and production.
  - Materials of Engineering Sciences: The students are able to apply methods of mechanical engineering to the design and analysis of engineering materials.
  - Mechatronics: The students are able to analyze mechatronic systems and their functions under consideration of aspects of electrical and mechanical engineering.
  - Product Development and Production: The students are able to apply standard methods to the design of production processes.
  - Theorectical Mechanical Engineering: The students are able to simulate mechanical and energy systems.

**Social competency**

- The students are able to present the approach and outcome of their work comprehensibly in writing as well as orally.
- The students are able to communicate with experts and laypersons about subject matters and problems of mechanical engineering. They are able to react appropriately to enquiries, complements, and comments.
- The students are able to work in groups. They are able to define, distribute, and integrate subtasks. They are able to reach agreements in terms of time and to interact socially.

**Independence**

- The students are able to obtain necessary specialist information and to put it into the context of their knowledge.
- The students are able to assess their competences realistically and to compensate for shortcomings independently.
- The students are able to acquire knowledge and skills of topic areas and problems in a self-organized and self-motivated manner (lifelong learning in engineering).

## Program structure

The course of studies consists of the core qualification in the extent of 150 credit points, a specialization in the extent of 18 credit points and the final work intended in the sixth semester in the extent of 12 credit points.

Specializations are: Energy technology, airplane-system technology, materials in the engineer's sciences, mechatronics, product development and production, as well as theoretical mechanical engineering.

# Core Qualification

Within this block "Kernqualifikation" of the Bachelor of Science program the students get the basics knowledge, basic professional skills and methods as a base for the further development of their competence up the ability to work qualified and responsable and to apply their skills on the job. Scientific principle-base education in mathemetics and the basics of engineering science are the essential topics of this block. First field applications, basics in business administration and nontechnical complementary courses are an important complement to these fields.

## Module M0577: Non-technical 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**<br><br>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.<br><br>**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. |
| *Skills* | **Professional Competence (Skills)**<br><br>In selected sub-areas students can |

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

## Module M0850: Mathematics I

**Courses**

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

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|---|---|
| **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. |
| **Workload in Hours** | Independent Study Time 128, Study Time in Lecture 112 |
| **Credit points** | 8 |
| **Course achievement** | Compulsory: Yes; Bonus: 10 %; Form: Excercises; Description: |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Logistics and Mobility: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| Course L2970: Mathematics I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 4 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 64, Study Time in Lecture 56 |
| **Lecturer** | Prof. Anusch Taraz |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Mathematical Foundations:<br><br>sets, statements, induction, mappings, trigonometry<br><br>Analysis: Foundations of differential calculus in one variable<br><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<br><br>Linear Algebra: Foundations of linear algebra in $R^n$<br><br>• vectors: rules, linear combinations, inner and cross product, lines and planes<br>• systems of linear equations: Gauß elimination, linear mappings, matrix multiplication, inverse matrices, determinants<br>• orthogonal projection in R^n, Gram-Schmidt-Orthonormalization |
| **Literature** | • T. Arens u.a. : Mathematik, Springer Spektrum, Heidelberg 2015<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 L2971: Mathematics I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Anusch Taraz, Dr. Dennis Clemens, Dr. Simon Campese |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

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

## Module M0933: Fundamentals of Materials Science

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of Materials Science I (L1085) | Lecture | 2 | 2 |
| Fundamentals of Materials Science II (Advanced Ceramic Materials, Polymers and Composites) (L0506) | Lecture | 2 | 2 |
| Physical and Chemical Basics of Materials Science (L1095) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Jörg Weißmüller |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Highschool-level physics, chemistry und mathematics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students have acquired a fundamental knowledge on metals, ceramics and polymers and can describe this knowledge comprehensively. Fundamental knowledge here means specifically the issues of atomic structure, microstructure, phase diagrams, phase transformations, corrosion and mechanical properties. The students know about the key aspects of characterization methods for materials and can identify relevant approaches for characterizing specific properties. They are able to trace materials phenomena back to the underlying physical and chemical laws of nature. |
| *Skills* | The students are able to trace materials phenomena back to the underlying physical and chemical laws of nature. Materials phenomena here refers to mechanical properties such as strength, ductility, and stiffness, chemical properties such as corrosion resistance, and to phase transformations such as solidification, precipitation, or melting. The students can explain the relation between processing conditions and the materials microstructure, and they can account for the impact of microstructure on the material's behavior. |
| **Personal Competence** | |
| *Social Competence* | - |
| *Autonomy* | - |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical 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 Advanced Materials: Compulsory<br>Data Science: Specialisation II. Application: Elective Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory |

| Course L1085: Fundamentals of Materials Science I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Jörg Weißmüller |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | Vorlesungsskript<br><br>W.D. Callister: Materials Science and Engineering - An Introduction. 5th ed., John Wiley & Sons, Inc., New York, 2000, ISBN 0-471-32013-7<br><br>P. Haasen: Physikalische Metallkunde. Springer 1994 |

| Course L0506: Fundamentals of Materials Science II (Advanced Ceramic Materials, Polymers and Composites) | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Bodo Fiedler, Prof. Gerold Schneider |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Chemische Bindungen und Aufbau von Festkörpern; Kristallaufbau; Werkstoffprüfung; Schweißbarkeit; Herstellung von Keramiken; Aufbau und Eigenschaften der Keramik; Herstellung, Aufbau und Eigenschaften von Gläsern; Polymerwerkstoffe, Makromolekularer Aufbau; Struktur und Eigenschaften der Polymere; Polymerverarbeitung; Verbundwerkstoffe |
| **Literature** | Vorlesungsskript<br><br>W.D. Callister: Materials Science and Engineering -An Introduction-5th ed., John Wiley & Sons, Inc., New York, 2000, ISBN 0-471-32013-7 |

| Course L1095: Physical and Chemical Basics of Materials Science | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Gregor Vonbun-Feldbauer |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Motivation: „Atoms in Mechanical Engineering?“<br>• Basics: Force and Energy<br>• The electromagnetic Interaction<br>• „Detour“: Mathematics (complex e-funktion etc.)<br>• The atom: Bohr's model of the atom<br>• Chemical bounds<br>• The multi part problem: Solutions and strategies<br>• Descriptions of using statistical thermodynamics<br>• Elastic theory of atoms<br>• Consequences of atomar properties on makroskopic Properties: Discussion of examples (metals, semiconductors, hybrid systems) |
| **Literature** | Für den **Elektromagnetismus:**<br>• Bergmann-Schäfer: „Lehrbuch der Experimentalphysik“, Band 2: „Elektromagnetismus“, de Gruyter<br>Für die **Atomphysik:**<br>• Haken, Wolf: „Atom- und Quantenphysik“, Springer<br>Für die **Materialphysik und Elastizität:**<br>• Hornbogen, Warlimont: „Metallkunde“, Springer |

## Module M1006: Team Project MB

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Team Project MB (L1236) | Project-/problem-based Learning | 6 | 6 |

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|---|---|
| **Module Responsible** | Prof. Bodo Fiedler |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **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 civil 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 civil engineering to the process of solving practical problems. They identify and overcome typical problems during the realization of projects in the context of civil 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 civil 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 civil engineering problem independently or in groups and discuss advantages as well as drawbacks. |
| *Autonomy* | Students are capable of independently solving mechanical 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 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | 2 h at Milestones (in rooms of the institutes) |
| **Assignment for the Following Curricula** | Mechanical Engineering: Core Qualification: Compulsory |

### Course L1236: Team Project MB

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|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 6 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Lecturer** | Prof. Bodo Fiedler, Dozenten des SD M |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | N/A |
| **Literature** | Unterlagen zur Organisation über Stud.IP |

## Module M1692: Computer Science for Engineers - Introduction and Overview

**Courses**

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

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|---|---|
| **Module Responsible** | Prof. Görschwin Fey |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Elementary knowledge of programming as taught in the "Introduction to Programming" bridge course or school. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The module provides prospective engineers with an overview of computer science as a discipline and of the fundamentals of programming. The aim is to facilitate the exchange between engineers and computer scientists and to show possibilities and limitations of programmable systems.<br><br>Basic knowledge is learned about<br>• approaches for estimating runtime and memory requirements<br>• computer architecture<br>• automata theory<br>• simple data structures like lists and fields<br>• sorting algorithms<br>• programming<br>• modeling for software<br>• unit testing testing and debugging |
| *Skills* | Basic programming skills are learned. Students can<br>• describe basic components of a computer<br>• select appropriate data structures for a problem solution<br>• design and implement simple programs<br>• apply unit testing<br>• estimate the runtime and memory requirements of simple algorithms |
| **Personal Competence** | |
| *Social Competence* | Students are able to develop and communicate computer science solutions in small multidisciplinary project teams. |
| *Autonomy* | Students can independently create small programs to solve simple problems and validate their correctness. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |

**Course achievement**

| Compulsory | Bonus | Form | Description |
|---|---|---|---|
| No | 10 % | Attestation | Testate finden semesterbegleitend statt. |

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| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Logistics and Mobility: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| Course L2685: Computer Science for Engineers - Introduction and Overview | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Görschwin Fey |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | • Informatik<br>  ◦ Helmut Herold, Bruno Lurz, Jürgen Wohlrab, Matthias Hopf: Grundlagen der Informatik, 3. Auflage, 816 Seiten, Pearson Studium, 2017.<br>• C++<br>  ◦ Bjarne Stroustrup, Einführung in die Programmierung mit C++, 479 Seiten, Pearson Studium, 2010.<br>  --> in der englischen Version bereits eine neuere Auflage!<br>  ◦ Jürgen Wolf : Grundkurs C++: C++-Programmierung verständlich erklärt, Rheinwerk Computing, 3. Auflage, 2016. |

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

## Module M1802: Engineering Mechanics I (Stereostatics)

**Courses**

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

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

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

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

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

## Module M1803: Engineering Mechanics II (Elastostatics)

**Courses**

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

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

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

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

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

## Module M0725: Production Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Production Engineering I (L0608) | Lecture | 2 | 2 |
| Production Engineering I (L0612) | Recitation Section (large) | 1 | 1 |
| Production Engineering II (L0610) | Lecture | 2 | 2 |
| Production Engineering II (L0611) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Jan Hendrik Dege |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | no course assessments required<br><br>internship recommended |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to ...<br><br>• name basic criteria for the selection of manufacturing processes.<br>• name the main groups of Manufacturing Technology.<br>• name the application areas of different manufacturing processes.<br>• name boundaries, advantages and disadvantages of the different manufacturing process.<br>• describe elements, geometric properties and kinematic variables and requirements for tools, workpiece and process.<br>• explain the essential models of manufacturing technology. |
| *Skills* | Students are able to...<br><br>• select manufacturing processes in accordance with the requirements.<br>• design manufacturing processes for simple tasks to meet the required tolerances of the component to be produced.<br>• assess components in terms of their production-oriented construction. |
| **Personal Competence** | |
| *Social Competence* | Students are able to ...<br><br>• develop solutions in a production environment with qualified personnel at technical level and represent decisions. |
| *Autonomy* | Students are able to ..<br><br>• interpret independently the manufacturing process.<br>• assess own strengths and weaknesses in general.<br>• assess their learning progress and define gaps to be improved.<br>• assess possible consequences of their actions. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Logistics and Mobility: Specialisation Production Management and Processes: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Specialisation Naval Engineering: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Elective Compulsory<br>Mechatronics: Specialisation Medical Engineering: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Compulsory |

| Course L0608: Production Engineering I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Jan Hendrik Dege |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Manufacturing Accuracy<br>• Manufacturing Metrology<br>• Measurement Errors and Uncertainties<br>• Introduction to Forming<br>• Massiv forming and Sheet Metal Forming<br>• Introduction to Machining Technology<br>• Geometrically defined machining (Turning, milling, drilling, broaching, planning) |
| **Literature** | Dubbel, Heinrich (Grote, Karl-Heinrich.; Feldhusen, Jörg.; Dietz, Peter,; Ziegmann, Gerhard,;) Taschenbuch für den Maschinenbau : mit Tabellen. Berlin [u.a.] : Springer, 2007<br><br>Fritz, Alfred Herbert: Fertigungstechnik : mit 62 Tabellen. Berlin [u.a.] : Springer, 2004<br><br>Keferstein, Claus P (Dutschke, Wolfgang,;): Fertigungsmesstechnik : praxisorientierte Grundlagen, moderne Messverfahren. Wiesbaden : Teubner, 2008<br><br>Mohr, Richard: Statistik für Ingenieure und Naturwissenschaftler : Grundlagen und Anwendung statistischer Verfahren. Renningen : expert-Verl, 2008<br><br>Klocke, F., König, W.: Fertigungsverfahren Bd. 1 Drehen, Fäsen, Bohren. 8. Aufl., Springer (2008)<br><br>Klocke, Fritz (König, Wilfried,;): Umformen. Berlin [u.a.] : Springer, 2006<br><br>Paucksch, E.: Zerspantechnik, Vieweg-Verlag, 1996<br><br>Tönshoff, H.K.; Denkena, B., Spanen. Grundlagen, Springer-Verlag (2004) |

| Course L0612: Production Engineering I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Jan Hendrik Dege |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0610: Production Engineering II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Jan Hendrik Dege, Prof. Claus Emmelmann |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Geometrically undefined machining (grinding, lapping, honing)<br>• Introduction into erosion technology<br>• Introduction into blastig processes<br>• Introduction to the manufacturing process forming (Casting, Powder Metallurgy, Composites)<br>• Fundamentals of Laser Technology<br>• Process versions and Fundamentals of Laser Joining Technology |
| **Literature** | Klocke, F., König, W.: Fertigungsverfahren Bd. 2 Schleifen, Honen, Läppen, 4. Aufl., Springer (2005)<br><br>Klocke, F., König, W.: Fertigungsverfahren Bd. 3 Abtragen, Generieren und Lasermaterialbearbeitung. 4. Aufl., Springer (2007)<br><br>Spur, Günter (Stöferle, Theodor.;): Urformen. München [u.a.] : Hanser, 1981<br><br>Schatt, Werner (Wieters, Klaus-Peter,; Kieback, Bernd,;): Pulvermetallurgie : Technologien und Werkstoffe. Berlin [u.a.] : Springer, 2007 |

| Course L0611: Production Engineering II | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Jan Hendrik Dege, Prof. Claus Emmelmann |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0594: Fundamentals of Mechanical Engineering Design

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of Mechanical Engineering Design (L0258) | Lecture | 2 | 3 |
| Fundamentals of Mechanical Engineering Design (L0259) | Recitation Section (large) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Dieter Krause |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Basic knowledge about mechanics and production engineering<br>• Internship (Stage I Practical) |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After passing the module, students are able to:<br>• explain basic working principles and functions of machine elements,<br>• explain requirements, selection criteria, application scenarios and practical examples of basic machine elements, indicate the background of dimensioning calculations. |
| *Skills* | After passing the module, students are able to:<br>• accomplish dimensioning calculations of covered machine elements,<br>• transfer knowledge learned in the module to new requirements and tasks (problem solving skills),<br>• recognize the content of technical drawings and schematic sketches,<br>• technically evaluate basic designs. |
| **Personal Competence** | |
| *Social Competence* | • Students are able to discuss technical information in the lecture supported by activating methods. |
| *Autonomy* | • Students are able to independently deepen their acquired knowledge in exercises.<br>• Students are able to acquire additional knowledge and to recapitulate poorly understood content e.g. by using the video recordings of the lectures. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Compulsory<br>Engineering Science: Specialisation Biomedical Engineering: Compulsory<br>Engineering Science: Specialisation Mechatronics: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory |

| Course L0258: Fundamentals of Mechanical Engineering Design | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause, Prof. Nikola Bursac, Prof. Sören Ehlers |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | **Lecture**<br>• Introduction to design<br>• Introduction to the following machine elements<br>  ◦ Screws<br>  ◦ Shaft-hub joints<br>  ◦ Rolling contact bearings<br>  ◦ Welding / adhesive / solder joints<br>  ◦ Springs<br>  ◦ Axes & shafts<br>• Presentation of technical objects (technical drawing)<br>**Exercise**<br>• Calculation methods for dimensioning the following machine elements:<br>  ◦ Screws<br>  ◦ Shaft-hub joints<br>  ◦ Rolling contact bearings<br>  ◦ Welding / adhesive / solder joints<br>  ◦ Springs<br>  ◦ Axis & shafts |
| **Literature** | • Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage.<br>• Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage.<br>• Einführung in die DIN-Normen; Klein, M., Teubner-Verlag.<br>• Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage.<br>• Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage.<br>• Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage.<br>• Sowie weitere Bücher zu speziellen Themen |

| Course L0259: Fundamentals of Mechanical Engineering Design | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause, Prof. Nikola Bursac, Prof. Sören Ehlers |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0671: Technical Thermodynamics I

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Technical Thermodynamics I (L0437) | Lecture | 2 | 4 |
| Technical Thermodynamics I (L0439) | Recitation Section (large) | 1 | 1 |
| Technical Thermodynamics I (L0441) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Arne Speerforck |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Elementary knowledge in Mathematics and Mechanics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are familiar with the laws of Thermodynamics. They know the relation of the kinds of energy according to 1 $^{st}$ law of Thermodynamics and are aware about the limits of energy conversions according to 2$^{nd}$ law of Thermodynamics. They are able to distinguish between state variables and process variables and know the meaning of different state variables like temperature, enthalpy, entropy and also the meaning of exergy and anergy. They are able to draw the Carnot cycle in a Thermodynamics related diagram. They know the physical difference between an ideal and a real gas and are able to use the related equations of state. They know the meaning of a fundamental state of equation and know the basics of two phase Thermodynamics. |
| *Skills* | Students are able to calculate the internal energy, the enthalpy, the kinetic and the potential energy as well as work and heat for simple change of states and to use this calculations for the Carnot cycle. They are able to calculate state variables for an ideal and for a real gas from measured thermal state variables. |
| **Personal Competence** | |
| *Social Competence* | The students can discuss in small groups and work out a solution. You can answer comprehension questions about the content that are provided in the lecture with the ClickerOnline tool "TurningPoint" after discussions with other students. |
| *Autonomy* | Students can understand the problems posed in tasks physically. They are able to select the methods taught in the lecture and exercise to solve problems and apply them independently to different types of tasks. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Compulsory<br>Engineering Science: Specialisation Mechatronics: Elective Compulsory<br>Engineering Science: Specialisation Biomedical Engineering: Compulsory<br>Engineering Science: Specialisation Advanced Materials: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Elective Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory |

| Course L0437: Technical Thermodynamics I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Arne Speerforck |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction<br>2. Fundamental terms<br>3. Thermal Equilibrium and temperature<br>3.1 Thermal equation of state<br>4. First law<br>4.1 Heat and work<br>4.2 First law for closed systems<br>4.3 First law for open systems<br>4.4 Examples<br>5. Equations of state and changes of state<br>5.1 Changes of state<br>5.2 Cycle processes<br>6. Second law<br>6.1 Carnot process<br>6.2 Entropy<br>6.3 Examples<br>6.4 Exergy<br>7. Thermodynamic properties of pure fluids<br>7.1 Fundamental equations of Thermodynamics<br>7.2 Thermodynamic potentials<br>7.3 Calorific state variables for arbritary fluids<br>7.4 state equations (van der Waals u.a.) |
| **Literature** | • Schmitz, G.: Technische Thermodynamik, TuTech Verlag, Hamburg, 2009<br>• Baehr, H.D.; Kabelac, S.: Thermodynamik, 15. Auflage, Springer Verlag, Berlin 2012<br>• Potter, M.; Somerton, C.: Thermodynamics for Engineers, Mc GrawHill, 1993 |

| Course L0439: Technical Thermodynamics I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Arne Speerforck |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0441: Technical Thermodynamics I | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Arne Speerforck |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0851: Mathematics II

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Prof. Anusch Taraz |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mathematics I |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can name further concepts in analysis and linear algebra. They are able to explain them using appropriate examples.<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. |
| **Workload in Hours** | Independent Study Time 128, Study Time in Lecture 112 |
| **Credit points** | 8 |
| **Course achievement** | Compulsory: Yes; Bonus: 10 %; Form: Excercises; Description: |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Digital Mechanical Engineering: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Integrated Building Technology: Core Qualification: Compulsory<br>Logistics and Mobility: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory |

| Course L2976: Mathematics II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 4 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 64, Study Time in Lecture 56 |
| **Lecturer** | Prof. Anusch Taraz |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Analysis:<br>• 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<br>Linear Algebra:<br>• 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 L2977: Mathematics II | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Anusch Taraz |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

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

## Module M0597: Advanced Mechanical Engineering Design

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Advanced Mechanical Engineering Design II (L0264) | Lecture | 2 | 2 |
| Advanced Mechanical Engineering Design II (L0265) | Recitation Section (large) | 2 | 1 |
| Advanced Mechanical Engineering Design I (L0262) | Lecture | 2 | 2 |
| Advanced Mechanical Engineering Design I (L0263) | Recitation Section (large) | 2 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Dieter Krause |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Fundamentals of Mechanical Engineering Design<br>• Mechanics<br>• Fundamentals of Materials Science<br>• Production Engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After passing the module, students are able to:<br>• explain complex working principles and functions of machine elements and of basic elements of fluidics,<br>• explain requirements, selection criteria, application scenarios and practical examples of complex machine elements,<br>• indicate the background of dimensioning calculations. |
| *Skills* | After passing the module, students are able to:<br>• accomplish dimensioning calculations of covered machine elements,<br>• transfer knowledge learned in the module to new requirements and tasks (problem solving skills),<br>• recognize the content of technical drawings and schematic sketches,<br>• evaluate complex designs, technically. |
| **Personal Competence** | |
| *Social Competence* | • Students are able to discuss technical information in the lecture supported by activating methods. |
| *Autonomy* | • Students are able to independently deepen their acquired knowledge in exercises.<br>• Students are able to acquire additional knowledge and to recapitulate poorly understood content e.g. by using the video recordings of the lectures. |
| **Workload in Hours** | Independent Study Time 68, Study Time in Lecture 112 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering: Compulsory<br>Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Naval Architecture: Core Qualification: Compulsory |

| Course L0264: Advanced Mechanical Engineering Design II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause, Prof. Nikola Bursac |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | **Advanced Mechanical Engineering Design I & II**<br><br>**Lecture**<br><br>• Fundamentals of the following machine elements:<br>  ◦ Linear rolling bearings<br>  ◦ Axes & shafts<br>  ◦ Seals<br>  ◦ Clutches & brakes<br>  ◦ Belt & chain drives<br>  ◦ Gear drives<br>  ◦ Epicyclic gears<br>  ◦ Crank drives<br>  ◦ Sliding bearings<br>• Elements of fluidics<br><br>**Exercise**<br><br>• Calculation methods of the following machine elements:<br>  ◦ Linear rolling bearings<br>  ◦ Axes & shafts<br>  ◦ Clutches & brakes<br>  ◦ Belt & chain drives<br>  ◦ Gear drives<br>  ◦ Epicyclic gears<br>  ◦ Crank gears<br>  ◦ Sliding bearings<br>• Calculations of hydrostatic systems (fluidics) |
| **Literature** | • Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage.<br>• Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage.<br>• Einführung in die DIN-Normen; Klein, M., Teubner-Verlag.<br>• Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage.<br>• Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage.<br>• Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage.<br><br>Sowie weitere Bücher zu speziellen Themen |

| Course L0265: Advanced Mechanical Engineering Design II | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 2, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause, Prof. Nikola Bursac |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0262: Advanced Mechanical Engineering Design I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause, Prof. Nikola Bursac |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | **Advanced Mechanical Engineering Design I & II**<br><br>**Lecture**<br><br>• Fundamentals of the following machine elements:<br>  ◦ Linear rolling bearings<br>  ◦ Axes & shafts<br>  ◦ Seals<br>  ◦ Clutches & brakes<br>  ◦ Belt & chain drives<br>  ◦ Gear drives<br>  ◦ Epicyclic gears<br>  ◦ Crank drives<br>  ◦ Sliding bearings<br>• Elements of fluidics<br><br>**Exercise**<br><br>• Calculation methods of the following machine elements:<br>  ◦ Linear rolling bearings<br>  ◦ Axes & shafts<br>  ◦ Clutches & brakes<br>  ◦ Belt & chain drives<br>  ◦ Gear drives<br>  ◦ Epicyclic gears<br>  ◦ Crank gears<br>  ◦ Sliding bearings<br>• Calculations of hydrostatic systems (fluidics) |
| **Literature** | • Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage.<br>• Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage.<br>• Einführung in die DIN-Normen; Klein, M., Teubner-Verlag.<br>• Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage.<br>• Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage.<br>• Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage.<br><br>Sowie weitere Bücher zu speziellen Themen |

| Course L0263: Advanced Mechanical Engineering Design I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 2, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause, Prof. Nikola Bursac |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0598: Mechanical Engineering: Design

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Embodiment Design and 3D-CAD Introduction and Practical Training (L0268) | Lecture | 2 | 1 |
| Mechanical Design Project I (L0695) | Project-/problem-based Learning | 3 | 2 |
| Mechanical Design Project II (L0592) | Project-/problem-based Learning | 3 | 2 |
| Team Project Design Methodology (L0267) | Project-/problem-based Learning | 2 | 1 |

**Module Responsible**: Prof. Dieter Krause

**Admission Requirements**: None

**Recommended Previous Knowledge**

- Fundamentals of Mechanical Engineering Design
- Mechanics
- Fundamentals of Materials Science
- Production Engineering

**Educational Objectives**: After taking part successfully, students have reached the following learning results

**Professional Competence**

*Knowledge*: After passing the module, students are able to:

- explain design guidelines for machinery parts e.g. considering load situation, materials and manufacturing requirements,
- describe basics of 3D CAD,
- explain basics methods of engineering designing.

*Skills*: After passing the module, students are able to:

- independently create sketches, technical drawings and documentations e.g. using 3D CAD,
- design components based on design guidelines autonomously,
- dimension (calculate) used components,
- use methods to design and solve engineering design tasks systamtically and solution-oriented,
- apply creativity techniques in teams.

**Personal Competence**

*Social Competence*: After passing the module, students are able to:

- develop and evaluate solutions in groups including making and documenting decisions,
- moderate the use of scientific methods,
- present and discuss solutions and technical drawings within groups,
- reflect the own results in the work groups of the course.

*Autonomy*: Students are able

- to estimate their level of knowledge using activating methods within the lectures (e.g. with clickers),
- To solve engineering design tasks systematically.

**Workload in Hours**: Independent Study Time 40, Study Time in Lecture 140

**Credit points**: 6

**Course achievement**

| Compulsory | Bonus | Form | Description |
|---|---|---|---|
| Yes | None | Written elaboration | Konstruktionsprojekt 2 |
| Yes | None | Written elaboration | 3D-CAD-Praktikum |
| Yes | None | Written elaboration | Teamprojekt Konstruktionsmethodik |
| Yes | None | Written elaboration | Konstruktionsprojekt 1 |

**Examination**: Written exam

**Examination duration and scale**: 180 min

**Assignment for the Following Curricula**

General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering: Compulsory
General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory
Engineering Science: Specialisation Mechanical Engineering: Compulsory
Engineering Science: Specialisation Biomedical Engineering: Compulsory
Engineering Science: Specialisation Mechatronics: Compulsory
Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory
Mechanical Engineering: Core Qualification: Compulsory
Mechatronics: Core Qualification: Compulsory
Naval Architecture: Core Qualification: Compulsory

| Course L0268: Embodiment Design and 3D-CAD Introduction and Practical Training | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 2, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Basics of 3D CAD technology<br>• Practical course to apply a 3D CAD system<br>  ◦ Introduction to the system<br>  ◦ Sketching and creation of components<br>  ◦ Creation of assemblies<br>  ◦ Deriving technical drawings |
| **Literature** | • CAx für Ingenieure eine praxisbezogene Einführung; Vajna, S., Weber, C., Bley, H., Zeman, K.; Springer-Verlag, aktuelle Auflage.<br>• Handbuch Konstruktion; Rieg, F., Steinhilper, R.; Hanser; aktuelle Auflage.<br>• Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage.<br>• Technisches Zeichnen: Grundlagen, Normen, Beispiele, Darstellende Geometrie, Hoischen, H; Hesser, W; Cornelsen, aktuelle Auflage.<br>• Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage.<br>• Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage.<br>• Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage.<br>• Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage.<br>• Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage. |

| Course L0695: Mechanical Design Project I | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 3 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 18, Study Time in Lecture 42 |
| **Lecturer** | Prof. Thorsten Schüppstuhl |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Create a technical documentation of an existing mechanical model<br>• Consolidation of the following aspects of technical drawings:<br>  ◦ Presentation of technical objects and standardized parts<br>  (bearings, seals, shaft-hub joints, detachable connections, springs, axes and shafts)<br>  ◦ Sectional views<br>  ◦ Dimensioning<br>  ◦ Tolerances and surface specifications<br>  ◦ Creating a tally sheet |
| **Literature** | 1. Hoischen, H.; Hesser, W.: Technisches Zeichnen. Grundlagen, Normen, Beispiele, darstellende Geometrie, 33. Auflage. Berlin 2011.<br>2. Labisch, S.; Weber, C.: Technisches Zeichnen. Selbstständig lernen und effektiv üben, 4. Auflage. Wiesbaden 2008.<br>3. Fischer, U.: Tabellenbuch Metall, 43. Auflage. Haan-Gruiten 2005. |

| Course L0592: Mechanical Design Project II | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 3 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 18, Study Time in Lecture 42 |
| **Lecturer** | Prof. Jan Hendrik Dege |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Generation of sketches for functions and sub-functions<br>• Approximately calculation of shafts<br>• Dimension of bearings, screw connections and weld<br>• Generation of engineering drawings (assembly drawings, manufacturing drawing) |
| **Literature** | **Dubbel, Taschenbuch für Maschinenbau**, Beitz, W., Küttner, K.-H, Springer-Verlag.<br>Maschinenelemente, Band I - III, Niemann, G., Springer-Verlag.<br>**Maschinen- und Konstruktionselemente**, Steinhilper, W., Röper, R., Springer-Verlag.<br>Einführung in die DIN-Normen, Klein, M., Teubner-Verlag.<br>Konstruktionslehre, Pahl, G., Beitz, W., Springer-Verlag. |

| Course L0267: Team Project Design Methodology | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 2, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Introduction to engineering designing methodology<br>• Team Project Design Methodology<br>  ◦ Creating requirement lists<br>  ◦ Problem formulation<br>  ◦ Creating functional structures<br>  ◦ Finding solutions<br>  ◦ Evaluation of the found concepts<br>  ◦ Documentation of the taken methodological steps and the concepts using presentation slides |
| **Literature** | • Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage.<br>• Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage.<br>• Einführung in die DIN-Normen; Klein, M., Teubner-Verlag.<br>• Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage.<br>• Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage.<br>• Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage.<br>• Sowie weitere Bücher zu speziellen Themen |

## Module M0608: Basics of Electrical Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Basics of Electrical Engineering (L0290) | Lecture | 3 | 4 |
| Basics of Electrical Engineering (L0292) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Thorsten Kern |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of mathematics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can to draw and explain circuit diagrams for electric and electronic circuits with a small number of components. They can describe the basic function of electric and electronic componentes and can present the corresponding equations. They can demonstrate the use of the standard methods for calculations. |
| *Skills* | Students are able to analyse electric and electronic circuits with few components and to calculate selected quantities in the circuits. They apply the ususal methods of the electrical engineering for this. |
| **Personal Competence** | |
| *Social Competence* | Students are enabled to collaborate in interdisciplinary teams with electrical engineering as a common language<br>With this, they are learning communication in a target-oriented communication style, are able to understand interfaces to neighboring engineering disciplines and learn about commonalities but also limits in the different directions of engineering. |
| *Autonomy* | Students are able independently to analyse electric and electronic circuits and to calculate selected quantities in the circuits. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>No / 20 % / Subject theoretical and practical work / Während des Semesters werden Hausarbeiten in Form von elektrischen Aufgaben vergeben, für die durch Simulation eine Lösung entwickelt und nachgewiesen werden muss. |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | 135 minutes |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory<br>Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Traffic Planning and Systems: Elective Compulsory |

### Course L0290: Basics of Electrical Engineering

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Thorsten Kern |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | DC networks: Current, voltage, power, Kirchhoff's laws, equivalent sources, network analysis<br>AC: Characteristics, RMS, complexe representation, phasor diagrams, power<br>Three phase AC: Characterisitics, star-delta- connection, power, transformer<br>Elektronics: Principle, operating behaviour and application of electronic devises as diode, Zener-diode, thyristor, transistor operational amplifier |
| **Literature** | Alexander von Weiss, Manfred Krause: "Allgemeine Elektrotechnik"; Viweg-Verlag, Signatur der Bibliothek der TUHH: ETB 309<br>Ralf Kories, Heinz Schmitt - Walter: "Taschenbuch der Elektrotechnik"; Verlag Harri Deutsch; Signatur der Bibliothek der TUHH: ETB 122<br>"Grundlagen der Elektrotechnik" - andere Autoren |

| Course L0292: Basics of Electrical Engineering | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thorsten Kern, Weitere Mitarbeiter |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Excercises to the analysis of circuits and the calculation of electrical quantities th the topics:<br><br>DC networks: Current, voltage, power, Kirchhoff's laws, equivalent sources,<br>network analysis<br><br>AC: Characteristics, RMS, complexe representation, phasor diagrams, power<br>Three phase AC: Characterisitics, star-delta- connection, power, transformer<br><br>Elektronics: Principle, operating behaviour and application of electronic devises as diode, Zener-diode, thyristor, transistor operational amplifier |
| **Literature** | Alexander von Weiss, Manfred Krause: "Allgemeine Elektrotechnik"; Viweg-Verlag, Signatur der Bibliothek der TUHH: ETB 309<br>Ralf Kories, Heinz Schmitt - Walter: "Taschenbuch der Elektrotechnik"; Verlag Harri Deutsch; Signatur der Bibliothek der TUHH: ETB 122<br>"Grundlagen der Elektrotechnik" - andere Autoren |

## Module M0688: Technical Thermodynamics II

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Technical Thermodynamics II (L0449) | Lecture | 2 | 4 |
| Technical Thermodynamics II (L0450) | Recitation Section (large) | 1 | 1 |
| Technical Thermodynamics II (L0451) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Arne Speerforck |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Elementary knowledge in Mathematics, Mechanics and Technical Thermodynamics I |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are familiar with different cycle processes like Joule, Otto, Diesel, Stirling, Seiliger and Clausius-Rankine. They are able to derive energetic and exergetic efficiencies and know the influence different factors. They know the difference between anti clockwise and clockwise cycles (heat-power cycle, cooling cycle). They have increased knowledge of steam cycles and are able to draw the different cycles in Thermodynamics related diagrams. They know the laws of gas mixtures, especially of humid air processes and are able to perform simple combustion calculations. They are provided with basic knowledge in gas dynamics and know the definition of the speed of sound and know about a Laval nozzle. |
| *Skills* | Students are able to use thermodynamic laws for the design of technical processes. Especially they are able to formulate energy, exergy- and entropy balances and by this to optimise technical processes. They are able to perform simple safety calculations in regard to an outflowing gas from a tank. They are able to transform a verbal formulated message into an abstract formal procedure. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss in small groups and develop an approach. You can answer comprehension questions about the content that are provided in the lecture with the ClickerOnline tool "TurningPoint" after discussions with other students. |
| *Autonomy* | Students can physically understand and explain the complex problems (cycle processes, air conditioning processes, combustion processes) set in tasks. They are able to select the methods taught in the lecture and exercise to solve complex problems and apply them independently to different types of tasks. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L0449: Technical Thermodynamics II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Arne Speerforck |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | 8. Cycle processes<br>7. Gas - vapor - mixtures<br>10. Open sytems with constant flow rates<br>11. Combustion processes<br>12. Special fields of Thermodynamics |
| **Literature** | • Schmitz, G.: Technische Thermodynamik, TuTech Verlag, Hamburg, 2009<br>• Baehr, H.D.; Kabelac, S.: Thermodynamik, 15. Auflage, Springer Verlag, Berlin 2012<br>• Potter, M.; Somerton, C.: Thermodynamics for Engineers, Mc GrawHill, 1993 |

| Course L0450: Technical Thermodynamics II | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Arne Speerforck |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0451: Technical Thermodynamics II | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Arne Speerforck |
| **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 |

| | |
|---|---|
| **Module Responsible** | Prof. Marko Lindner |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mathematics I + II |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can name the basic concepts in the area of analysis and differential equations. They are able to explain them using appropriate examples.<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. |
| **Workload in Hours** | Independent Study Time 128, Study Time in Lecture 112 |
| **Credit points** | 8 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min (Analysis III) + 60 min (Differential Equations 1) |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory<br>Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory<br>Logistics and Mobility: Specialisation Information Technology: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Traffic Planning and Systems: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Information Technology: Compulsory |

| Course L1028: Analysis III | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dozenten des Fachbereiches Mathematik der UHH |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Main features of differential and integrational calculus of several variables<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>• Fourier series<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 M1804: Engineering Mechanics III (Dynamics)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Engineering Mechanics III (Dynamics) (L1134) | Lecture | 3 | 3 |
| Engineering Mechanics III (Dynamics) (L1136) | Recitation Section (large) | 1 | 1 |
| Engineering Mechanics III (Dynamics) (L1135) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Robert Seifried |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mathematics I, II, Engineering Mechanics I (Statics). Parallel to Engineering Mechanik III the module Mathematics III should be attended. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can<br>• describe the axiomatic procedure used in mechanical contexts;<br>• explain important steps in model design;<br>• present technical knowledge in kinematics, kinetics and vibrations. |
| *Skills* | The students can<br>• explain the important elements of mathematical / mechanical analysis and model formation, and apply it to the context of their own problems;<br>• apply basic kinematic, kinetic and vibraton methods to engineering problems;<br>• estimate the reach and boundaries of kinematic, kinetic and vibraton methods and extend them to be applicable to wider problem sets. |
| **Personal Competence** | |
| *Social Competence* | The students can work in groups and support each other to overcome difficulties. |
| *Autonomy* | Students are capable of determining their own strengths and weaknesses and to organize their time and learning based on those. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: No; Bonus: 20 %; Form: Midterm; Description: Midterm |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Specialisation Naval Engineering: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Medical Engineering: Compulsory<br>Mechatronics: Specialisation Dynamic Systems and AI: Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| Course L1134: Engineering Mechanics III (Dynamics) | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Robert Seifried |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Kinematics<br>1.1 Motion of a particle<br>1.2 Planar motion of a rigid body<br>1.3 Spatial motion of a rigid body<br>1.4 Spatial relative Kinematics<br><br>2 Kinetics<br>2.1 Linear momentum and change of linear momentum<br><br>2.2 Angular momentum and change of angular momentum<br>2.3 Kinetics of rigid bodies<br>2.4 Energy and balance of energy<br><br>3 Vibrations<br>3.1 Classification of Vibrations<br>3.2 Free undamped vibration<br>3.3 Free damped vibration<br>3.4 Forced vibration<br><br>4. Impact problems<br><br>5 Kinetics of gyroscopes<br>5.1 Free gyroscopic motion<br>5.2 Forced gyroscopic motion |
| **Literature** | K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009).<br>D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 3 und 4. 11. Auflage, Springer (2011). |

| Course L1136: Engineering Mechanics III (Dynamics) | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Robert Seifried |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1135: Engineering Mechanics III (Dynamics) | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Robert Seifried |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0610: Electrical Machines and Actuators

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Prof. Thorsten Kern |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of mathematics, in particular complexe numbers, integrals, differentials<br><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><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 are able to calculate two-dimensional electric and magnetic fields in particular ferromagnetic circuits with air gap. For this they apply the usual methods of the design auf electric machines.<br><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 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | Design of four machines and actuators, review of design files |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective 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 Mechatronics: Elective Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Elective Compulsory<br>Engineering Science: Specialisation Electrical Engineering: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory<br>Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory<br>Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Elective Compulsory<br>Mechatronics: Specialisation Naval Engineering: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Electrical Systems: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Information Technology: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Traffic Planning and Systems: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Elective Compulsory |

| Course L0293: Electrical Machines and Actuators | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Thorsten Kern, Dennis Kähler |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Electric field: Coulomb´s law, flux (field) line, work, potential, capacitor, energy, force, capacitive actuators<br><br>Magnetic field: force, flux line, Ampere´s law, field at bounderies, flux, magnetic circuit, hysteresis, induction, self-induction, mutual inductance, transformer, electromagnetic actuators<br><br>Synchronous machines, construction and layout, equivalent single line diagrams, no-load and short-cuircuit characteristics, vector diagrams, motor and generator operation, stepper motors<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 (squirrel-cage vs. sliprings),<br><br>Drives with variable speed, inverter fed operation, special drives |
| **Literature** | Hermann Linse, Roland Fischer: "Elektrotechnik für Maschinenbauer", Vieweg-Verlag; Signatur der Bibliothek der TUHH: ETB 313<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 and Actuators | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thorsten Kern, Dennis Kähler |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0680: Fluid Dynamics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fluid Mechanics (L0454) | Lecture | 3 | 4 |
| Fluid Mechanics (L0455) | Recitation Section (large) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Thomas Rung |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Students should have sound knowledge of engineering mathematics, engineering mechanics and thermodynamics. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students will have the required sound knowledge to explain the general principles of fluid engineering and physics of fluids. They are familiar with the similarities and differences between fluid mechanics and neighbouring subjects (thermodynamics, structural mechanics). Students can scientifically outline the rationale of flow physics using mathematical models. They are familiar with most performance analysis methods -in particular their realms and limitations- and the prediction of fluid engineering devices. |
| *Skills* | Students are able to apply fluid-engineering principles and flow-physics models for the analysis of technical systems. They are able to explain physical relationships used to design fluid engineering devices. The lecture enables the student to carry out all necessary theoretical calculations for the fluid dynamic design of engineering devices on a scientific level. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss problems, present the results of their own analysis, and jointly develop solution strategies that address given technical goals. |
| *Autonomy* | The students are able to develop solution strategies for complex problems self-consistent. They are able to critically analyse own results as well as external data with regards to the plausibility and reliability. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical 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>Mechanical Engineering: Core Qualification: Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| Course L0454: Fluid Mechanics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Thomas Rung |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | • continuum physics definition of fluids, difference to solids/structures and material properties of fluids<br>• dimensional analysis and similitude<br>• fluid forces and fluid statics<br>• transport and conservation of mass, momentum & energy<br>• fluid kinematics<br>• technically relevant flow models for incompressible fluids<br>  ◦ control volume & stream tube analysis<br>  ◦ vortical flow models<br>  ◦ potential flows<br>  ◦ boundary layer flows<br>  ◦ different types of conservation equations and their realm (Navier-Stokes/Euler/Bernoulli equations)<br>  ◦ analytical solutions for Navier-Stokes systems<br>• Analysis of internal flows (channels, pipes, open channels) and external flows, fundamentals of wing aerodynamics<br>• turbulent flows<br>• fundamentals of gas dynamics (1D compressible flows) |
| **Literature** | • the course primarily refers to / das Modul stütz sich bevorzugt auf :<br>Munson, B.R.; Rothmayer, A.P.; Okiishi, T.H.; Huebsch, W.W.: **Fundamentals of Fluid Mechanics**, John Wiley & Sons.<br>• Spurk, J.; Aksel, N.: Strömungslehre, Springer.<br>• Schade, H.; Kunz, E., Kameier, F.; Paschereit, C.O.: Strömungslehere, De Gruyter.<br>• Herwig, H.: Strömungsmechanik, Springer.<br>• Herwig, H.: Strömungsmechanik von A-Z, Vieweg. |

| Course L0455: Fluid Mechanics | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thomas Rung |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0865: Fundamentals of Production and Quality Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Production Process Organization (L0925) | Lecture | 2 | 3 |
| Quality Management (L0926) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Hermann Lödding |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | None |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to explain the contents of the lecture of the module. |
| *Skills* | Students are able to apply the methods and models in the module to industrial problems. |
| **Personal Competence** | |
| *Social Competence* | - |
| *Autonomy* | - |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 Minutes |
| **Assignment for the Following Curricula** | 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 Product Development and Production: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Elective Compulsory<br>Engineering Science: Specialisation Mechatronics: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory<br>Engineering Science: Specialisation Advanced Materials: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering and Management: Compulsory<br>Logistics and Mobility: Specialisation Production Management and Processes: Compulsory<br>Mechanical Engineering: Core Qualification: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Compulsory |

### Course L0925: Production Process Organization

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Hermann Lödding |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | (A) Introduction<br>(B) Product planning<br>(C) Process planning<br>(D) Procurement<br>(E) Manufacturing<br>(F) Production planning and control (PPC)<br>(G) Distribution<br>(H) Cooperation |
| **Literature** | Wiendahl, H.-P.: Betriebsorganisation für Ingenieure<br>Vorlesungsskript |

| Course L0926: Quality Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Hermann Lödding |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Definition and Relevance of Quality<br>• Continuous Quality Improvement<br>• Quality Management in Product Development<br>• Quality Management in Production Processes<br>• Design of Experiments |
| **Literature** | • Pfeifer, Tilo: Quality Management. Strategies, Methods, Techniques; Hanser-Verlag, München 2002<br>• Pfeifer, Tilo: Qualitätsmanagement. Strategien, Methoden, Techniken; Hanser-Verlag, München, 3. Aufl. 2001<br>• Mitra, Amitava: Fundamentals of Quality Control and Improvement; Wiley; Macmillan, 2008<br>• Kleppmann, W.: Taschenbuch Versuchsplanung. Produkte und Prozesse optimieren; Hanser-Verlag, München, 6. Aufl. 2009 |

## Module M0934: Advanced Materials for Sustainability

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Advanced Materials Characterization (L1087) | Lecture | 2 | 2 |
| Advanced Materials for Sustainability (L1091) | Lecture | 2 | 2 |
| Advanced Materials for Sustainability (L1092) | Recitation Section (large) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Patrick Huber |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals of Materials Science (I and II) |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students will be able to explain the properties of advanced materials along with their applications in technology, in particular metallic, ceramic, polymeric, semiconductor, modern composite materials (biomaterials) and nanomaterials. |
| *Skills* | The students will be able to select material configurations according to the technical needs and, if necessary, to design new materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview on modern materials science, which enables them to select optimum materials combinations depending on the technical applications. |
| **Personal Competence** | |
| *Social Competence* | The students are able to present solutions to specialists and to develop ideas further. |
| *Autonomy* | The students are able to ...<br>• assess their own strengths and weaknesses.<br>• define tasks independently. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory<br>Engineering Science: Specialisation Advanced Materials: Compulsory<br>Mechanical Engineering: Core Qualification: Elective Compulsory |

### Course L1087: Advanced Materials Characterization

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Patrick Huber |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | |
| **Literature** | William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011).<br>William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007). |

| Course L1091: Advanced Materials for Sustainability | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Patrick Huber, Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Kaline Pagnan Furlan, Prof. Robert Meißner |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | |
| **Literature** | Vorlesungsunterlagen |

| Course L1092: Advanced Materials for Sustainability | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Patrick Huber, Prof. Stefan Fritz Müller |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1805: Computational Mechanics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Computational Mechanics (Exercises) (L1138) | Recitation Section (small) | 2 | 2 |
| Computational Multibody Dynamics (L1137) | Integrated Lecture | 2 | 2 |
| Computational Stuctural Mechanics (L2475) | Integrated Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Robert Seifried |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mathematics I-III and Engineering Mechanics I-III |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can<br>• describe the axiomatic procedure used in mechanical contexts;<br>• explain important steps in model design;<br>• present technical knowledge. |
| *Skills* | The students can<br>• explain the important elements of mathematical / mechanical analysis and model formation, and apply it to the context of their own problems;<br>• apply basic methods from numerical mechanics to engineering problems;<br>• estimate the reach and boundaries of the methods and extend them to be applicable to wider problem sets. |
| **Personal Competence** | |
| *Social Competence* | The students can work in groups and support each other to overcome difficulties. |
| *Autonomy* | Students are capable of determining their own strengths and weaknesses and to organize their time and learning based on those. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |

**Course achievement**

| Compulsory | Bonus | Form | Description |
|---|---|---|---|
| No | 15 % | Midterm | Midterm Mehrkörpersysteme |
| No | 5 % | Excercises | Hausaufgaben |

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|---|---|
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical 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>Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Medical Engineering: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory |

### Course L1138: Computational Mechanics (Exercises)

| | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Robert Seifried, Prof. Christian Cyron |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | |
| **Literature** | K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009).<br>D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1-4. 11. Auflage, Springer (2011). |

| Course L1137: Computational Multibody Dynamics | |
|---|---|
| **Typ** | Integrated Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Robert Seifried |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Modelling of mechanical systems<br>• Linear versus nonlinear vibration<br>• Numerical methods for time integration<br>• Vibrations with multiple degrees of freedom: free, damped, forced, modal transformation<br>• Concepts from analytical mechanics<br>• Spatial multibody systems<br>• Linearization of multibody systems<br>• Introduction to Matlab |
| **Literature** | K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009).<br>D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1-4. 11. Auflage, Springer (2011).<br>W. Schiehlen, P. Eberhard: Technische Dynamik, Springer (2012). |

| Course L2475: Computational Stuctural Mechanics | |
|---|---|
| **Typ** | Integrated Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Cyron, Dr. Kevin Linka |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The lecture Computational Structural Mechanics extends the content of the lecture Engineering Mechanic II. It bridges the gap between the manual calculation of mechanical stress and deformation in systems with a particularly simple geometry and the efficent computer-based computation of general mechanical systems:<br>• Basics of linear continuum mechanics<br>• Planar structures: plate, membrane, slab<br>• Linientragwerke: beam, cable, truss<br>• Weak form and Galerkin's method<br>• Finite element method: theory and application<br>• Principles of mechanics: principle of virtual work, virtual displacements, virtual forces |
| **Literature** | Gross, Hauger, Wriggers, "Technische Mechanik 4", Springer |

## 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 |

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|---|---|
| **Module Responsible** | Prof. Timm Faulwasser |
| **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<br>• They can apply stability analysis via the Rough-Hurwitz criterion<br>• The can map systems vom the Laplace domain to the time domain and obtain a state-space description<br>• The can do pole-placement control designs for SISO systems and analyze controllability of LTI Systems |
| *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 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Data Science: Specialisation II. Application: Elective Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Logistics and Mobility: Specialisation Information Technology: Elective Compulsory<br>Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory<br>Logistics and Mobility: Specialisation Production Management and Processes: 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<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Information Technology: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Traffic Planning and Systems: Elective Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Elective |

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|---|---|
| | 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. Timm Faulwasser |
| **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. Timm Faulwasser |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M2184: Measurement Technology for Mechanical Engineers

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Practical Course: Measurement and Control Systems (L1119) | Practical Course | 2 | 2 |
| Measurement Technology for Mechanical Engineering (L1116) | Lecture | 2 | 2 |
| Measurement Technology for Mechanical Engineering (L1118) | Practical Course | 2 | 2 |

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| **Module Responsible** | Prof. Thorsten Kern |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge of physics, chemistry and electrical engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to name the most important fundmentals of the Measurement Technology (Quantities and Units, Uncertainty, Calibration, Static and Dynamic Properties of Sensors and Systems).<br><br>They can outline the most important measuring methods for different kinds of quantities to be maesured (Electrical Quantities, Temperature, mechanical quantities, Flow, Time, Frequency).<br><br>They can describe important methods of chemical Analysis (Gas Sensors, Spectroscopy, Gas Chromatography) |
| *Skills* | Students can select suitable measuring methods to given problems and can use refering measurement devices in practice.<br><br>The students are able to orally explain issues in the subject area of measurement technology and solution approaches as well as place the issues into the right context and application area. |
| **Personal Competence** | |
| *Social Competence* | Students can arrive at work results in groups and document them in a common report. |
| *Autonomy* | Students are able to familiarize themselves with new measurement technologies. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes; **Bonus** None; **Form** Subject theoretical and practical work; **Description** |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | Successfull execution of up to 12 short experiments on measurements technology and sucessfull participation in the practical course of "Practical Course: Measurement and Control Systems" |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Compulsory<br>Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory<br>Engineering Science: Specialisation Mechatronics: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering and Management: Compulsory<br>Engineering Science: Specialisation Advanced Materials: Elective Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechatronics: Specialisation Dynamic Systems and AI: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Medical Engineering: Compulsory<br>Mechatronics: Specialisation Naval Engineering: Compulsory<br>Mechatronics: Specialisation Electrical Systems: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Production Management and Processes: Elective Compulsory |

### Course L1119: Practical Course: Measurement and Control Systems

| | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thorsten Kern |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | **The content of experiment 1:**<br><br>Accuracy testing of a delta robot: In the course of the experiment, the accuracy of a delta robot is tested through 3 tasks. The first task focuses on the online/offline programming of the robot. The second task deals with sensor calibration. In the third task, the |

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|---|---|
| | radius of a sphere is determined using three different measurement methods (manual measurement, manual measurement with a sensor, automatic data acquisition and data processing).<br><br>**The content of experiment 3:**<br><br>The aim of the task is to enable the parallel kinematics to find objects, grasp them and place them on a static target position For this purpose, the end effector of the kinematics is equipped with an optical sensor (camera), whose characteristics are to be defined. The measuring range of the sensor is to be identified and, based on this, a movement strategy for finding the objects is to be developed and implemented. Once the objects have been found, they are to be picked up with a magnetic gripper and transported to their destination.<br><br>**The content of experiment 4:**<br><br>The aim of the task is to enable the parallel kinematics to find objects, grab them and deposit them on a moving platform. For this purpose, the end effector of the kinematics is equipped with an optical sensor (camera), the properties of which were worked out in experiment 3. Based on this, the parallel kinematics should now be able to follow the moving platform. For this purpose, a position control must be developed and implemented. Once the controller has been appropriately configured, the objects can be placed on the moving platform. |
| **Literature** | Versuch 1:<br><br>• 1)Weck, Manfred; Brecher, Christian. Maschinenarten und Anwendungsbereiche. Springer (Werkzeugmaschinen, 1, Ed. 6). 2005<br>• 2)Weck, Manfred; Brecher, Christian. Automatisierung von Maschinen und Anlagen. Springer (Werkzeugmaschinen, 4, Ed. 6). 2006<br>• 3)Siciliano, Bruno; Khatib, Oussama. Springer handbook of robotics. Springer. 2008<br>• 4)Schüppstuhl, Thorsten. VL Grundlagen der Handhabungs- und Montagetechnik. 2017<br><br>Versuch 3:<br><br>• 1)Hompel, Michael, Hubert Büchter, and Ulrich Franzke. Identifikationssysteme und Automatisierung. Springer-Verlag, 2007.<br>• ArUco Library Documentation, https://docs.google.com/document/d/1QU9KoBtjSM2kF6ITOjQ76xqL7H0TEtXrIJX5kwi9Kgc/edit Stand 10/21<br>• Demant, Christian, Bernd Streicher-Abel, and Axel Springhoff. Industrielle Bildverarbeitung: wie optische Qualitätskontrolle wirklich funktioniert. Springer-Verlag, 2011.<br><br>Versuch 4:<br><br>• 1)Will, Thorsten T. C++ Das umfassende Handbuch, Rheinwerk Computing, 2020<br>• 2)Hildebrand, Walter. Grundkurs Regelungstechnik : Grundlagen für Bachelorstudiengänge aller technischen Fachrichtungen und Wirtschaftsingenieure, Springer Vieweg, 2013.<br>• 3)Erlenkötter, Helmut. C++: Objektorientiertes Programmieren von Anfang an, rororo, 2016<br><br>Bibliography:<br><br>Experiment 1<br><br>• 1)Weck, Manfred; Brecher, Christian. Maschinenarten und Anwendungsbereiche. Springer (Werkzeugmaschinen, 1, Ed. 6). 2005<br>• 2)Weck, Manfred; Brecher, Christian. Automatisierung von Maschinen und Anlagen. Springer (Werkzeugmaschinen, 4, Ed. 6). 2006<br>• 3)Siciliano, Bruno; Khatib, Oussama. Springer handbook of robotics. Springer. 2008<br>• 4)Schüppstuhl, Thorsten. VL Grundlagen der Handhabungs- und Montagetechnik. 2017<br><br>Experiment 3:<br><br>• 1)Hompel, Michael, Hubert Büchter, and Ulrich Franzke. Identifikationssysteme und Automatisierung. Springer-Verlag, 2007.<br>• ArUco Library Documentation, https://docs.google.com/document/d/1QU9KoBtjSM2kF6ITOjQ76xqL7H0TEtXrIJX5kwi9Kgc/edit Stand 10/21<br>• Demant, Christian, Bernd Streicher-Abel, and Axel Springhoff. Industrielle Bildverarbeitung: wie optische Qualitätskontrolle wirklich funktioniert. Springer-Verlag, 2011.<br><br>Experiment 4:<br><br>• 1)Will, Thorsten T. C++ Das umfassende Handbuch, Rheinwerk Computing, 2020<br>• 2)Hildebrand, Walter. Grundkurs Regelungstechnik : Grundlagen für Bachelorstudiengänge aller technischen Fachrichtungen und Wirtschaftsingenieure, Springer Vieweg, 2013.<br>• 3)Erlenkötter, Helmut. C++: Objektorientiertes Programmieren von Anfang an, rororo, 2016 |

| Course L1116: Measurement Technology for Mechanical Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thorsten Kern, Dennis Kähler |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | 1 Fundamentals<br>1.1 Quantities and Units<br>1.2 Uncertainty<br>1.3 Calibration<br>1.4 Static and Dynamic Properties of Sensors and Systems<br>2 Measurement of Electrical Quantities<br>2.1 Current and Voltage<br>2.2 Impedance<br>2.3 Amplification<br>2.4 Oscilloscope<br>2.5 Analog-to-Digital Conversion<br>2.6 Data Transmission<br>3 Measurement of Nonelectric Quantities<br>3.1 Temperature<br>3.2 Length, Displacement, Angle<br>3.3 Strain, Force, Pressure<br>3.4 Flow<br>3.5 Time, Frequency |
| **Literature** | Lerch, R.: „Elektrische Messtechnik; Analoge, digitale und computergestützte Verfahren“, Springer, 2006, ISBN: 978-3-540-34055-3.<br>Profos, P. Pfeifer, T.: „Handbuch der industriellen Messtechnik“, Oldenbourg, 2002, ISBN: 978-3486217940. |

| Course L1118: Measurement Technology for Mechanical Engineering | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thorsten Kern |
| **Language** | EN |
| **Cycle** | WiSe/SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0596: Advanced Mechanical Design Project

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Advanced Mechanical Design Project (L0266) | Project-/problem-based Learning | 4 | 6 |

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|---|---|
| **Module Responsible** | Dr. Jens Schmidt |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Mechanical Engineering: Design<br>• Advanced Mechanical Engineering Design |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After passing the module, students are able to:<br>• express the procedure for systematically handling of<br>• complex design tasks ,<br>• describe working principles, their use and combination possibilities,<br>• explain guidelines for designing for function and manufacturing,<br>• explain advanced use-oriented knowledge of machine elements. |
| *Skills* | After passing the module, students are able to:<br>• analyze complex tasks and develop principle solutions using sketches,<br>• convert principle solutions into a detailed design,<br>• use methods to design and solve engineering design tasks systematically and solution-oriented,<br>• create a technical documentation including all necessary technical drawings to understand the functions of the system,<br>• document calculations of selected machine elements clearly and in detail. |
| **Personal Competence** | |
| *Social Competence* | After passing the module, students are able to:<br>• present and discuss solutions and technical drawings within groups,<br>• reflect the own results in the work groups of the course |
| *Autonomy* | After passing the module, students are able to:<br>• independently solve complex design projects, while motivating themselves, acquiring necessary knowledge and selecting appropriate methods,<br>• to independently solve problems. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes; **Bonus** None; **Form** Attestation; **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 |
| **Assignment for the Following Curricula** | 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 Product Development and Production: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory |

| Course L0266: Advanced Mechanical Design Project | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 4 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Lecturer** | Dr. Jens Schmidt, Dr. Volkert Wollesen |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The Advanced Mechanical Design Project consists of two parts, the gearbox design and the conceptional design.<br>• Gearbox design in individual work<br>- Development of solution principles<br>- Calculation of machine elements<br>- Design of a gearbox in the main section plus all external views<br>- Preparation of a detailed documentation<br>• Conceptional design<br>- Methodical development and drawing of conceptual solutions<br>- Preparation of a detailed documentation<br>• |
| **Literature** | • Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage.<br>• Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage.<br>• Einführung in die DIN-Normen; Klein, M., Teubner-Verlag.<br>• Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage.<br>• Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage.<br>• Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage.<br>• Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage.<br>• Sowie weitere Bücher zu speziellen Themen |

## Module M0829: Foundations of Management

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Prof. Christian Lüthje |
| **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. |
| *Autonomy* | Students are able to<br>• 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 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | several written exams during the semester plus final test (90 minutes) |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Civil- and Environmental Engineering: Specialisation Civil Engineering: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Water and Environment: Elective Compulsory<br>Civil- and Environmental Engineering: Specialisation Traffic and Mobility: Elective Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Bio Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical Engineering: Elective Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Systems / Renewable Energies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Water Technologies: Elective Compulsory |

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|---|---|
| | Computer Science in Engineering: Core Qualification: Compulsory<br>Logistics and Mobility: Core Qualification: Compulsory<br>Mechanical Engineering: Core Qualification: Compulsory<br>Mechanical Engineering: Specialisation Biomechanics: Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Compulsory<br>Mechanical Engineering: Specialisation Materials in Engineering Sciences: Compulsory<br>Mechanical Engineering: Specialisation Product Development and Production: Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Compulsory<br>Mechatronics: Specialisation Electrical Systems: Compulsory<br>Mechatronics: Specialisation Medical Engineering: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory<br>Mechatronics: Specialisation Naval Engineering: Compulsory<br>Mechatronics: Specialisation Dynamic Systems and AI: Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Core Qualification: Compulsory<br>Process Engineering: Core Qualification: Compulsory<br>~~Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory~~ |

| **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. Matthias Meyer, Prof. Christian Lüthje, Prof. Christian Ringle, Prof. Christian Thies, Prof. Christoph Ihl, Prof. Kathrin Fischer, Prof. Moritz Göldner, Prof. Thomas Wrona, Prof. Thorsten Blecker, Prof. Tim Schweisfurth, Prof. Wolfgang Kersten |
| **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. |

| Course L0882: Exercise Introduction to Management (Exercise) | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Lüthje |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | In this exercise, students develop the knowledge and skills to understand what it means to turn an idea for a new product or service into a real business idea and to start a start-up. The students work together in weekly group exercises and develop a business idea in teams of up to five people. Finally, they present their developed business ideas in the form of a final presentation and a corresponding pitch deck.<br><br>Why this course is essential:<br><br>Many students develop ideas for new products or services during their studies. This exercise provides them with the tools and basic knowledge to turn these ideas into reality. In the process, students learn to work creatively, structured, and in teams.<br><br>Content:<br><br>In ten weekly group exercises, students work out a business idea based on the following key questions:<br><br>1. How do you generate a relevant and viable business idea?<br>2. How do you develop a business model from a business idea?<br>3. How do you assess the market and potential customers for a specific product or service?<br>4. How do you develop a sales and distribution strategy?<br>5. How can you convince investors of a business idea and a business model to secure financing?<br><br>What you will learn and get:<br><br>At the end of this exercise, you will have gained an overview of what it means to start a start-up and the necessary steps to do so. Furthermore, you will have learned to transform your theoretical knowledge into practical business ideas and business models. In the process, you will have gained skills regarding teamwork. |
| **Literature** | Relevante Literatur aus der korrespondierenden Vorlesung. |

# Specialization Biomechanics

Due to the ever increasing demands on the health system of an aging population, mechanization is of great importance. Both individual implants and instruments as well as large appliances used for diagnostics and therapy, medical and engineering science staff must work increasingly close together to meet the new requirements. For engineers, this means that they can understand and influence project management, and development and research have what they learn in this specialization in addition to specific engineering fundamentals and medical and business aspects of patient care.

## Module M1277: MED I: Introduction to Anatomy

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Introduction to Anatomy (L0384) | Lecture | 2 | 3 |

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|---|---|
| **Module Responsible** | Prof. Michael Morlock |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Students can listen to the lectures without any prior knowledge. Basic school knowledge of biology, chemistry / biochemistry, physics and Latin can be useful. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The lectures are about microscopic anatomy, describing the microscopic structure of tissues and organs, and about macroscopic anatomy which is about organs and organ systems. The lectures also contain an introduction to cell biology, human development and to the central nervous system. The fundamentals of radiologic imaging are described as well, using projectional x-ray and cross-sectional images. The Latin terms are introduced. |
| *Skills* | At the end of the lecture series the students are able to describe the microscopic as well as the macroscopic assembly and functions of the human body. The Latin terms are the prerequisite to understand medical literature. This knowledge is needed to understand und further develop medical devices.<br><br>These insights in human anatomy are the fundamentals to explain the role of structure and function for the development of common diseases and their impact on the human body. |
| **Personal Competence** | |
| *Social Competence* | The students can participate in current discussions in biomedical research and medicine on a professional level. The Latin terms are prerequisite for communication with physicians on a professional level. |
| *Autonomy* | The lectures are an introduction to the basics of anatomy and should encourage students to improve their knowledge by themselves. Advice is given as to which further literature is suitable for this purpose. Likewise, the lecture series encourages students to recognize and think critically about biomedical problems. |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>Data Science: Specialisation II. Application: Elective Compulsory<br>Electrical Engineering and Information Technology: Specialisation Medical Technology: Elective Compulsory<br>Electrical Engineering: Specialisation Medical Technology: Elective Compulsory<br>Engineering Science: Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Biomechanics: Compulsory<br>Mechatronics: Specialisation Medical Engineering: Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| **Course L0384: Introduction to Anatomy** | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Thorsten Frenzel |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | **General Anatomy**<br><br>**1st week:** **The Eucaryote Cell**<br><br>**2nd week:** **The Tissues**<br><br>**3rd week:** **Cell Cycle, Basics in Development**<br><br>**4th week:** **Musculoskeletal System**<br><br>**5th week:** **Cardiovascular System**<br><br>**6th week:** **Respiratory System**<br><br>**7th week:** **Genito-urinary System**<br><br>**8th week:** **Immune system**<br><br>**9th week:** **Digestive System I**<br><br>**10th week:** **Digestive System II**<br><br>**11th week:** **Endocrine System**<br><br>**12th week:** **Nervous System**<br><br>**13th week:** **Exam** |
| **Literature** | Adolf Faller/Michael Schünke, Der Körper des Menschen, **18. Auflage**, Thieme Verlag Stuttgart, **2020**, 704 Seiten, ISBN 978-3-13-243820-0 |

## Module M1278: MED I: Introduction to Radiology and Radiation Therapy

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Introduction to Radiology and Radiation Therapy (L0383) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Michael Morlock |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | None |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | **Therapy**<br>The students can distinguish different types of currently used equipment with respect to its use in radiation therapy.<br>The students can explain treatment plans used in radiation therapy in interdisciplinary contexts (e.g. surgery, internal medicine).<br>**The students can describe the patients' passage from their initial admittance through to follow-up care.**<br>**Diagnostics**<br>The students can illustrate the technical base concepts of projection radiography, including angiography and mammography, as well as sectional imaging techniques (CT, MRT, US).<br>The students can explain the diagnostic as well as therapeutic use of imaging techniques, as well as the technical basis for those techniques.<br>The students can choose the right treatment method depending on the patient's clinical history and needs.<br>The student can explain the influence of technical errors on the imaging techniques.<br>The student can draw the right conclusions based on the images' diagnostic findings or the error protocol. |
| *Skills* | **Therapy**<br>The students can distinguish curative and palliative situations and motivate why they came to that conclusion.<br>The students can develop adequate therapy concepts and relate it to the radiation biological aspects.<br>The students can use the therapeutic principle (effects vs adverse effects)<br>The students can distinguish different kinds of radiation, can choose the best one depending on the situation (location of the tumor) and choose the energy needed in that situation (irradiation planning).<br>The student can assess what an individual psychosocial service should look like (e.g. follow-up treatment, sports, social help groups, self-help groups, social services, psycho-oncology).<br>**Diagnostics**<br>The students can suggest solutions for repairs of imaging instrumentation after having done error analyses.<br>The students can classify results of imaging techniques according to different groups of diseases based on their knowledge of anatomy, pathology and pathophysiology. |
| **Personal Competence** | |
| *Social Competence* | The students can assess the special social situation of tumor patients and interact with them in a professional way.<br>The students are aware of the special, often fear-dominated behavior of sick people caused by diagnostic and therapeutic measures and can meet them appropriately. |
| *Autonomy* | The students can apply their new knowledge and skills to a concrete therapy case.<br>The students can introduce younger students to the clinical daily routine.<br>The students are able to access anatomical knowledge by themselves, can participate competently in conversations on the topic and acquire the relevant knowledge themselves. |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>Data Science: Specialisation II. Application: Elective Compulsory<br>Electrical Engineering and Information Technology: Specialisation Medical Technology: Elective Compulsory<br>Electrical Engineering: Specialisation Medical Technology: Elective Compulsory<br>Engineering Science: Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory |

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

| **Course L0383: Introduction to Radiology and Radiation Therapy** | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Thorsten Frenzel |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The students will be given an understanding of the technological possibilities in the field of medical imaging, interventional radiology and radiation therapy/radiation oncology. It is assumed, that students in the beginning of the course have heard the word “X-ray” at best. It will be distinguished between the two arms of diagnostic (Prof. Dr. med. Thomas Vestring) and therapeutic (Prof. Dr. med. Ulrich Carl) use of X-rays. Both arms depend on special big units, which determine a predefined sequence in their respective departments |
| **Literature** | • "Technik der medizinischen Radiologie" von T. + J. Laubenberg -<br>7. Auflage - Deutscher Ärzteverlag - erschienen 1999<br>• "Klinische Strahlenbiologie" von Th. Herrmann, M. Baumann und W. Dörr -<br>4. Auflage - Verlag Urban & Fischer - erschienen 02.03.2006<br>ISBN: 978-3-437-23960-1<br>• "Strahlentherapie und Onkologie für MTA-R" von R. Sauer -<br>5. Auflage 2003 - Verlag Urban & Schwarzenberg - erschienen 08.12.2009<br>ISBN: 978-3-437-47501-6<br>• "Taschenatlas der Physiologie" von S. Silbernagel und A. Despopoulus-<br>8. Auflage - Georg Thieme Verlag - erschienen 19.09.2012<br>ISBN: 978-3-13-567708-8<br>• "Der Körper des Menschen " von A. Faller u. M. Schünke -<br>16. Auflage 2004 - Georg Thieme Verlag - erschienen 18.07.2012<br>ISBN: 978-3-13-329716-5<br>• „Praxismanual Strahlentherapie“ von Stöver / Feyer -<br>1. Auflage - Springer-Verlag GmbH - erschienen 02.06.2000 |

## Module M1279: MED II: Introduction to Biochemistry and Molecular Biology

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Introduction to Biochemistry and Molecular Biology (L0386) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Hans-Jürgen Kreienkamp |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | None |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can<br>• describe basic biomolecules;<br>• explain how genetic information is coded in the DNA;<br>• explain the connection between DNA and proteins; |
| *Skills* | The students can<br>• recognize the importance of molecular parameters for the course of a disease;<br>• describe selected molecular-diagnostic procedures;<br>• explain the relevance of these procedures for some diseases |
| **Personal Competence** | |
| *Social Competence* | The students can participate in discussions in research and medicine on a technical level.<br>Students will have an improved understanding of current medical problems (e.g. Corona pandemic)and will be able to explain these issues to others. |
| *Autonomy* | The students can develop an understanding of topics from the course, using technical literature, by themselves.<br>Students will be better equipped to recognize fake news in the media regarding medical research topics. |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>Electrical Engineering and Information Technology: Specialisation Medical Technology: Elective Compulsory<br>Electrical Engineering: Specialisation Medical Technology: Elective Compulsory<br>Engineering Science: Specialisation Biomedical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Biomechanics: Compulsory<br>Mechatronics: Specialisation Medical Engineering: Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| Course L0386: Introduction to Biochemistry and Molecular Biology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Hans-Jürgen Kreienkamp |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | Müller-Esterl, Biochemie, Spektrum Verlag, 2010; 2. Auflage<br><br>Löffler, Basiswissen Biochemie, 7. Auflage, Springer, 2008 |

## Module M1333: BIO I: Implants and Fracture Healing

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Implants and Fracture Healing (L0376) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Sara Checa Esteban |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | It is recommended to participate in "Introduction into Anatomie" before attending "Implants and Fracture Healing". |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can describe the different ways how bones heal, and the requirements for their existence.<br>The students can name different treatments for the spine and hollow bones under given fracture morphologies. |
| *Skills* | The students can determine the forces acting within the human body under quasi-static situations under specific assumptions. |
| **Personal Competence** | |
| *Social Competence* | The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces. |
| *Autonomy* | The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces. |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>Yes / 10 % / Presentation |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>Engineering Science: Specialisation Biomedical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Biomechanics: Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Orientation Studies: Core Qualification: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| Course L0376: Implants and Fracture Healing | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Sara Checa Esteban |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Topics to be covered include:<br>1. Introduction (history, definitions, background importance)<br>2. Bone (anatomy, properties, biology, adaptations in femur, tibia, humerus, radius)<br>3. Spine (anatomy, biomechanics, function, vertebral bodies, intervertebral disc, ligaments)<br>3.1 The spine in its entirety<br>3.2 Cervical spine<br>3.3 Thoracic spine<br>3.4 Lumbar spine<br>3.5 Injuries and diseases<br>4. Pelvis (anatomy, biomechanics, fracture treatment)<br>5 Fracture Healing<br>5.1 Basics and biology of fracture repair<br>5.2 Clinical principals and terminology of fracture treatment<br>5.3 Biomechanics of fracture treatment<br>5.3.1 Screws<br>5.3.2 Plates<br>5.3.3 Nails<br>5.3.4 External fixation devices<br>5.3.5 Spine implants<br>6.0 New Implants |
| **Literature** | Cochran V.B.: Orthopädische Biomechanik<br>Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics<br>White A.A., Panjabi M.M.: Clinical biomechanics of the spine<br>Nigg, B.: Biomechanics of the musculo-skeletal system<br>Schiebler T.H., Schmidt W.: Anatomie<br>Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat |

## Module M1280: MED II: Introduction to Physiology

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Introduction to Physiology (L0385) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Sara Checa Esteban |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | None |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can<br>• describe the basics of the energy metabolism;<br>• describe physiological relations in selected fields of muscle, heart/circulation, neuro- and sensory physiology. |
| *Skills* | The students can describe the effects of basic bodily functions (sensory, transmission and processing of information, development of forces and vital functions) and relate them to similar technical systems. |
| **Personal Competence** | |
| *Social Competence* | The students can conduct discussions in research and medicine on a technical level.<br>The students can find solutions to problems in the field of physiology, both analytical and metrological. |
| *Autonomy* | The students can derive answers to questions arising in the course and other physiological areas, using technical literature, by themselves. |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>Electrical Engineering and Information Technology: Specialisation Medical Technology: Elective Compulsory<br>Electrical Engineering: Specialisation Medical Technology: Elective Compulsory<br>Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory<br>Mechanical Engineering: Specialisation Biomechanics: Compulsory<br>Mechatronics: Specialisation Medical Engineering: Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

### Course L0385: Introduction to Physiology

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Gerhard Engler |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | |
| **Literature** | Taschenatlas der Physiologie, Silbernagl Despopoulos, ISBN 978-3-135-67707-1, Thieme<br><br>Repetitorium Physiologie, Speckmann, ISBN 978-3-437-42321-5, Elsevier |

## Module M1332: BIO I: Experimental Methods in Biomechanics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Experimental Methods in Biomechanics (L0377) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Dr. Gerd Huber |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | It is recommended to participate in "Implantate und Frakturheilung" before attending "Experimentelle Methoden". |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The course deals with common experimental methods used in biomechanics. For each topic an overview and some basic practical knowledge is provided.<br><br>1. Tribology<br>2. Optical Methods<br>3. Motion Analysis<br>4. Pressure Distribution<br>5. Strain Gauges<br>6. Pre-clinical testing<br>7. Specimen Preparation and Storage<br><br>The students can describe the different ways how bones heal, and the requirements for their existence.<br><br>The students can name different treatments for the spine and hollow bones under given fracture morphologies.<br><br>The students can describe different measurement techniques for forces and movements, and choose the adequate technique for a given task. |
| *Skills* | The students can describe the basic handling of several experimental techniques used in biomechanics. |
| **Personal Competence** | |
| *Social Competence* | Students are able to organize themselves as a group to solve simple experimental tasks together. On the one hand, the division of tasks must be organized during the experiment as well as during the short written elaboration, but on the other hand, the knowledge acquired must be available to all participants of the group afterwards. The challenge here is that the topics change quickly because fundamentally different measurement principles are taught. In addition, a strict time management is expected. |
| *Autonomy* | Students perform simple experimental tasks in small groups or create simple sensors (e.g. strain gauges). The preceding lecture serves as a basis for these experiments. As preparation or follow-up, the theoretical knowledge has to be worked up and related to the experimental result. In particular, independent transfer performance is necessary to clarify why experimental observations can show deviations from the theoretical values and how these deviations can be compensated. |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory<br>Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory<br>Mechanical Engineering: Specialisation Biomechanics: Compulsory<br>Mechatronics: Specialisation Medical Engineering: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| Course L0377: Experimental Methods in Biomechanics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Gerd Huber, Prof. Michael Morlock |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The course deals with common experimental methods used in biomechanics. For each topic an overview and some basic practical knowledge is provided.<br><br>1. Tribology<br>2. Optical Methods<br>3. Motion Analysis<br>4. Pressure Distribution<br>5. Strain Gauges<br>6. Pre-clinical testing<br>7. Specimen Preparation and Storage |
| **Literature** | Hoffmann K., Eine Einführung in die Technik des Messens mit Dehnmessstreifen<br><br>White A.A., Panjabi M.M.: Clinical biomechanics of the spine<br><br>Nigg, B.: Biomechanics of the musculo-skeletal system<br><br>Online Hilfe von Mathworks: https://de.mathworks.com/help/matlab/ |

# Specialization Energy Systems

The aim of this specialization is to familiarize students with different technologies for energy conversion, energy distribution and energy application. Processes can be analyzed using scientific methods, as well as abstracted and modeled, and are also documented. Students can evaluate data and results and from those develop strategies for the development of innovative solutions.

## Module M1022: Reciprocating Machinery

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of Reciprocating Engines and Turbomachinery - Part Reciprocating Engines (L0633) | Lecture | 1 | 1 |
| Fundamentals of Reciprocating Engines and Turbomachinery - Part Reciprocating Engines (L0634) | Recitation Section (large) | 1 | 1 |
| Internal Combustion Engines I (L0059) | Lecture | 2 | 2 |
| Internal Combustion Engines I (L0639) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Christopher Friedrich Wirz |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Thermodynamics, Mechanics, Machine Elements |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | As a result of the part module „Fundamentals of Reciprocating Machinery", the students are able to reflect fundamentals regarding power and working machinery and describe the qualitative and quantitative correlations of operating methods and efficiencies of multiple types of engines, compressors and pumps. They are able to utilize technical terms and parameters as well as aspects regarding the development of power density and efficiency, furthermore to give an overview of charging systems, fuels and emissions. The students are able to select specific types of machinery and assess design related and operational problems.<br><br>As a result of the part module "Internal Combustion Engines I", the students are able reflect and utilize the state-of-the-art regarding efficiency limits. In addition, they are able to utilize their knowledge of design, mechanical and thermodynamic characteristics and the approach of similarity. They are able to explain, assess and develop engines as well as charging systems. Detailed knowledge is present regarding computer-aided process design. |
| *Skills* | The students are skilled to employ basic and detail knowledge regarding reciprocating machinery, their selection and operation. They are further able to assess, analyse and solve technical and operational problems and to perform mechanical and thermodynamic design. |
| **Personal Competence** | |
| *Social Competence* | The students are able to communicate and cooperate in a professional environment in the field of machinery design and application. |
| *Autonomy* | The widespread scope of gained knowledge enables the students to handle situations in their future profession independently and confidently. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory<br>Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Compulsory |

| Course L0633: Fundamentals of Reciprocating Engines and Turbomachinery - Part Reciprocating Engines | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Christopher Friedrich Wirz |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Verbrennungsmotoren<br>  ◦ Historischer Rückblick<br>  ◦ Einteilung der Verbrennungsmotoren<br>  ◦ Arbeitsverfahren<br>  ◦ Vergleichsprozesse<br>  ◦ Arbeit, Mitteldrücke, Leistungen<br>  ◦ Arbeitsprozess des wirklichen Motors<br>  ◦ Wirkungsgrade<br>  ◦ Gemischbildung und Verbrennung<br>  ◦ Motorkennfeld und Betriebskennlinien<br>  ◦ Abgasentgiftung<br>  ◦ Gaswechsel<br>  ◦ Aufladung<br>  ◦ Kühl- und Schmiersystem<br>  ◦ Kräfte im Triebwerk<br>• Kolbenverdichter<br>  ◦ Thermodynamik des Kolbenverdichters<br>  ◦ Einteilung und Verwendung<br>• Kolbenpumpen<br>  ◦ Prinzip der Kolbenpumpen<br>  ◦ Einteilung und Verwendung |
| **Literature** | • A. Urlaub: Verbrennungsmotoren<br>• W. Kalide: Kraft- und Arbeitsmaschinen |

| Course L0634: Fundamentals of Reciprocating Engines and Turbomachinery - Part Reciprocating Engines | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Christopher Friedrich Wirz |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0059: Internal Combustion Engines I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christopher Severin |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • The beginnings of engine development<br>• Design of of motors<br>• Real process calculation<br>• Charging methods<br>• Kinematics of the crank mechanism<br>• Forces in the engine |
| **Literature** | • Vorlesungsskript<br>• Übungsaufgaben mit Lösungsweg<br>• Literaturliste |

| Course L0639: Internal Combustion Engines I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Christopher Severin |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0655: Computational Fluid Dynamics I

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Computational Fluid Dynamics I (L0235) | Lecture | 2 | 3 |
| Computational Fluid Dynamics I (L0419) | Recitation Section (large) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Thomas Rung |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Students should have sound knowledge of engineering mathematics (series expansions, internal & vector calculus), and be familiar with the foundations of partial/ordinary differential equations. They should also be familiar with engineering fluid mechanics and thermodynamics. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students will have the required combined knowledge of thermo-/fluid dynamics and numerical analysis to translate general principles of thermo-/fluid engineering into discrete algorithms on the basis of local (finite differences/volumes) and global (potential theory) ansatz functions. They are familiar with the similarities and differences between different discretisation and approximation concepts for investigating coupled systems of non-linear, convective partial differential equations (PDE), and explain the motivation for applying them. Students have the required background knowledge to develop, code, explain and apply numerical algorithms dedicated to the solution of thermofluid dynamic PDEs. They are familiar with most numerical methods used to predict thermofluid dynamic fields, in particular their realms and limitations. |
| *Skills* | The students are able choose and apply appropriate numerical procedures that integrate the governing thermofluid dynamic PDEs in space and time. They can apply/optimise numerical analysis concepts to/for fluid dynamic applications. They can code computational algorithms in a structured way, apply these codes for parameter investigations and supplement interfaces to extract simulation data for an engineering analysis. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss problems, present the results of their own analysis, and jointly develop, implement and report on solution strategies that address given technical reference problems. |
| *Autonomy* | The students can independently analyse numerical methods to solving fluid engineering problems. They are able to critically analyse own results as well as external data with regards to the plausibility and reliability. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 2h |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory<br>Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Naval Architecture: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

| Course L0235: Computational Fluid Dynamics I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Niklas Kühl |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Fundamentals of computational modelling of thermofluid dynamic problems. Development of numerical algorithms.<br><br>1. Partial differential equations<br>2. Foundations of finite numerical approximations<br>3. Computation of potential flows<br>4. Introduction of finite-differences<br>5. Approximation of convective, diffusive and transient transport processes<br>6. Formulation of boundary conditions and initial conditions<br>7. Assembly and solution of algebraic equation systems<br>8. Facets of weighted -residual approaches<br>9. Finite volume methods<br>10. Basics of grid generation |
| **Literature** | Ferziger and Peric: *Computational Methods for Fluid Dynamics*, Springer |

| Course L0419: Computational Fluid Dynamics I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Niklas Kühl |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0662: Numerical Mathematics I

**Courses**

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

| | |
|---|---|
| **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/Python 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/Python,<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 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory<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 Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Data Science: Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Elective Compulsory<br>Engineering Science: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective 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 |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | 1. Finite precision arithmetic, error analysis, conditioning and stability<br>2. Linear systems of equations: LU and Cholesky factorization, condition<br>3. Interpolation: polynomial, spline and trigonometric interpolation<br>4. Nonlinear equations: fixed point iteration, root finding algorithms, Newton's method<br>5. Linear and nonlinear least squares problems: normal equations, Gram Schmidt and Householder orthogonalization, singular value decomposition, regularizatio, Gauss-Newton and Levenberg-Marquardt methods<br>6. Eigenvalue problems: power iteration, inverse iteration, QR algorithm<br>7. Numerical differentiation<br>8. Numerical integration: Newton-Cotes rules, error estimates, Gauss quadrature, adaptive quadrature |
| **Literature** | • Gander/Gander/Kwok: Scientific Computing: An introduction using Maple and MATLAB, Springer (2014)<br>• 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. Jens-Peter Zemke |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0538: Heat and Mass Transfer

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Heat and Mass Transfer (L0101) | Lecture | 2 | 2 |
| Heat and Mass Transfer (L0102) | Recitation Section (small) | 2 | 2 |
| Heat and Mass Transfer (L1868) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Irina Smirnova |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge: Technical Thermodynamics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • The students are capable of explaining qualitative and determining quantitative heat transfer in procedural apparatus (e. g. heat exchanger, chemical reactors).<br>• They are capable of distinguish and characterize different kinds of heat transfer mechanisms namely heat conduction, heat transfer and thermal radiation.<br>• The students have the ability to explain the physical basis for mass transfer in detail and to describe mass transfer qualitative and quantitative by using suitable mass transfer theories.<br>• They are able to depict the analogy between heat- and mass transfer and to describe complex linked processes in detail. |
| *Skills* | • The students are able to set reasonable system boundaries for a given transport problem by using the gained knowledge and to balance the corresponding energy and mass flow, respectively.<br>• They are capable to solve specific heat transfer problems (e.g. heated chemical reactors, temperature alteration in fluids) and to calculate the corresponding heat flows.<br>• Using dimensionless quantities, the students can execute scaling up of technical processes or apparatus.<br>• They are able to distinguish between diffusion, convective mass transition and mass transfer. They can use this knowledge for the description and design of apparatus (e.g. extraction column, rectification column).<br>• In this context, the students are capable to choose and design fundamental types of heat and mass exchanger for a specific application considering their advantages and disadvantages, respectively.<br>• In addition, they can calculate both, steady-state and non-steady-state processes in procedural apparatus.<br>• The students are capable to connect their knowledge obtained in this course with knowlegde of other courses (In particular the courses thermodynamics, fluid mechanics and chemical process engineering) to solve concrete technical problems. |
| **Personal Competence** | |
| *Social Competence* | • The students are capable to work on subject-specific challenges in teams and to present the results orally in a reasonable manner to tutors and other students. |
| *Autonomy* | • The students are able to find and evaluate necessary information from suitable sources<br>• They are able to prove their level of knowledge during the course with accompanying procedure continuously (clicker-system, exam-like assignments) and on this basis they can control their learning processes. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 minutes; theoretical questions and calculations |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: 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 Biomedical Engineering: Compulsory<br>Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory |

| | |
|---|---|
| | Mechanical Engineering: Specialisation Energy Systems: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| **Course L0101: Heat and Mass Transfer** | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | 1. Heat transfer<br>  ◦ Introduction, one-dimensional heat conduction<br>  ◦ Convective heat transfer<br>  ◦ Multidimensional heat conduction<br>  ◦ Non-steady heat conduction<br>  ◦ Thermal radiation<br>2. Mass transfer<br>  ◦ one-way diffusion, equimolar countercurrent diffusion<br>  ◦ boundary layer theory, non-steady mass transfer<br>  ◦ Heat and mass transfer single particle/ fixed bed<br>  ◦ Mass transfer and chemical reactions |
| **Literature** | 1. H.D. Baehr und K. Stephan: Wärme- und Stoffübertragung, Springer<br>2. VDI-Wärmeatlas |

| **Course L0102: Heat and Mass Transfer** | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| **Course L1868: Heat and Mass Transfer** | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Irina Smirnova |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M2064: Introduction to Machine Learning for Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Introduction to Machine Learning for Engineering (L3333) | Lecture | 2 | 4 |
| Introduction to Machine Learning for Engineering (L3332) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Timm Faulwasser |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Linear algebra, differentiation of vector-valued functions, basic programming |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students learn basic techniques of Machine Learning. They he basic of selected ML techniques such as KNN, support vector macheines, Gaussian process and kernel regression. They are alos familar with neural network and their training |
| *Skills* | The students are able to decide whether given learning tasks from engineering are classification or regression problems. They know essenetial differences between unsupervised, supervised and reinforcement learning. They can formalize nonlinear programming problems via KKT conditions. They can apply basic concepts from statistics and stochastics. They can apply the following to simple problems: KNN, support vector macheines, Gaussian process and kernel regression and artificial neural networks. |
| **Personal Competence** | |
| *Social Competence* | The students can collaborate across boundaries of disciplines and in international teams. |
| *Autonomy* | The student can formulate questions and problems with respect to complex issues. They can program selected techniques on their own in Python. |
| **Workload in Hours** | Independent Study Time 138, Study Time in Lecture 42 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: No; Bonus: 20 %; Form: Midterm; Description: |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Elective Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory<br>Engineering Science: Specialisation Mechatronics: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering and Management: Elective Compulsory<br>Engineering Science: Specialisation Electrical Engineering: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Elective Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

### Course L3333: Introduction to Machine Learning for Engineering

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Timm Faulwasser |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L3332: Introduction to Machine Learning for Engineering | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Timm Faulwasser |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See modul description. |
| **Literature** | |

## Module M2176: Computer Science for Engineers - Programming Concepts, Data Handling & Communication

**Courses**

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

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

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

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

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

# Specialization Aircraft Systems Engineering

The specialization "Aircraft Systems" prepares students for a variety of careers in the aviation industry, and neighboring fields. Students will gain knowledge on how to deal with the methods of systems engineering, as well as the use of modern, computer-aided techniques for system design, analysis and evaluation. In addition, the necessary competencies of aeronautical engineering in aircraft systems, cabin systems, pneumatic conveying systems and aircraft design and flight physics and materials technology.

## Module M0599: Digital Product Development and Lightweight Design

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| CAE-Team Project (L0271) | Project-/problem-based Learning | 2 | 2 |
| Digital Product Development (L0269) | Lecture | 2 | 2 |
| Development of Lightweight Design Products (L0270) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Dieter Krause |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Advanced Knowledge about engineering design:<br><br>Fundamentals of Mechanical Engineering Design<br><br>Mechanical Engineering: Design<br><br>Advanced Mechanical Engineering Design |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After completing the module, students are capable of:<br><br>• explaining the functional principle of 3D-CAD-Systems, PDM- and FEM-Systems<br>• describing the interaction of the different CAE-Systems in the product development process |
| *Skills* | After completing the module, students are able to:<br><br>• evaluate different CAD- and PDM-Systems with regards to the desired requirements such as classification schemes and product structuring<br>• design an exemplary product using CAD-,PDM- and/or FEM-Systems with shared workload |
| **Personal Competence** | |
| *Social Competence* | After completing the module, students are able to:<br><br>• To develop a project plan and allocate work appropriate work packages in the framework of group discussions<br>• Present project results as a team for instance in a presentation |
| *Autonomy* | Students are capable of:<br><br>• independently adapt to a CAE-Tool and complete a given practical task with it |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: Yes; Bonus: 20 %; Form: Subject theoretical and practical work; Description: CAE-Teamprojekt inkl. Vortrag und Ausarbeitung |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 |
| **Assignment for the Following Curricula** | 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 Product Development and Production: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory<br>Mechanical Engineering: Specialisation Product Development and Production: Compulsory<br>Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory<br>Mechanical Engineering - Product Development and Production: Technical Complementary Course Core Studies: Elective Compulsory<br>Product Development, Materials and Production: Technical Complementary Course Core Studies: Elective Compulsory |

| Course L0271: CAE-Team Project | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Practical Introduction in the used software systems (Creo, Windchill, Hyperworks)<br>• Team formation, allocation of tasks and generation of a project plan<br>• Collective creation of one product out of CAD models supported by FEM calculations and PDM system<br>• Manufacturing of selected parts using 3D printer<br>• Presentation of results<br><br>**Description**<br><br>Part of the module is a project based team orientated practical course using the PBL method. In this course, students learn the handling of modern CAD, PDM and FEM systems (Creo, Windchill and Hyperworks). After a short introduction in the applied software systems, students work in teams on a task during the semester. The aim is the development of one product out of several CAD parts models using a PDM system including FEM calculations of selected parts and 3D printing of parts. The developed product must be presented in a joint presentation. |
| **Literature** | • Ehrlenspiel, K.: Integrierte Produktentwicklung, München, Carl Hanser Verlag<br>• Lee, K.: Principles of CAD / CAM / CAE Systems, Addison Wesles<br>• Schichtel, M.: Produktdatenmodellierung in der Praxis, München, Carl Hanser Verlag<br>• Anderl, R.: CAD Schnittstellen, München, Carl Hanser Verlag<br>• Spur, G., Krause, F.: Das virtuelle Produkt, München, Carl Hanser Verlag |

| Course L0269: Digital Product Development | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Introduction to Integrated Product Development<br>• 3D CAD -Systems and CAD interfaces<br>• Administration of part lists / PDM systems<br>• PDM in different industries<br>• Selection of CAD-/PDM Systems<br>• Simulation<br>• Construction methods<br>• Design for X |
| **Literature** | • Ehrlenspiel, K.: Integrierte Produktentwicklung, München, Carl Hanser Verlag<br>• Lee, K.: Principles of CAD / CAM / CAE Systems, Addison Wesles<br>• Schichtel, M.: Produktdatenmodellierung in der Praxis, München, Carl Hanser Verlag<br>• Anderl, R.: CAD Schnittstellen, München, Carl Hanser Verlag<br>• Spur, G., Krause, F.: Das virtuelle Produkt, München, Carl Hanser Verlag |

| Course L0270: Development of Lightweight Design Products | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause, Prof. Benedikt Kriegesmann |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Lightweight design materials<br>• Product development process for lightweight structures<br>• Dimensioning of lightweight structures |
| **Literature** | • Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, 2005.<br>• Klein, B., „Leichtbau-Konstruktion", Vieweg & Sohn, Braunschweig, 1989.<br>• Krause, D., „Leichtbau”, In: Handbuch Konstruktion, Hrsg.: Rieg, F., Steinhilper, R., München, Carl Hanser Verlag, 2012.<br>• Schulte, K., Fiedler, B., „Structure and Properties of Composite Materials”, Hamburg, TUHH - TuTech Innovation GmbH, 2005.<br>• Wiedemann, J., „Leichtbau Band 1: Elemente“, Springer, Berlin, Heidelberg, 1986. |

## Module M0767: Aeronautical Systems

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of Aircraft Systems (L0741) | Lecture | 2 | 2 |
| Fundamentals of Aircraft Systems (L0742) | Recitation Section (small) | 1 | 1 |
| Air Transportation Systems (L0591) | Lecture | 2 | 2 |
| Air Transportation Systems (L0816) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Frank Thielecke |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of mathematics, mechanics and thermodynamics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students get a basic understanding of the structure and design of an aircraft, as well as an overview of the systems inside an aircraft. In addition, a basic knowledge of the relationchips, the key parameters, roles and ways of working in different subsystems in the air transport is acquired. |
| *Skills* | Due to the learned cross-system thinking students can gain a deeper understanding of different system concepts and their technical system implementation. In addition, they can apply the learned methods for the design and assessment of subsystems of the air transportation system in the context of the overall system. |
| **Personal Competence** | |
| *Social Competence* | Students are made aware of interdisciplinary communication in groups. |
| *Autonomy* | Students are able to independently analyze different system concepts and their technical implementation as well as to think system oriented. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 150 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory<br>Data Science: Specialisation II. Application: Elective Compulsory<br>Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory<br>Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Specialisation II. Traffic Planning and Systems: Elective Compulsory |

### Course L0741: Fundamentals of Aircraft Systems

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Frank Thielecke |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Development of aircrafts, fundamentals of flight physics, propulsion systems, analysis of ranges and loads, aircraft-structures and materials<br>• Hydraulic and electrical power systems, landing gear systems, flight-control and high-lift systems, air conditioning systems |
| **Literature** | • Shevell, R. S.: Fundamentals of Flight<br>• TÜV Rheinland: Luftfahrtzeugtechnik in Theorie und Praxis<br>• Wild: Transport Category Aircraft Systems |

### Course L0742: Fundamentals of Aircraft Systems

| | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Frank Thielecke |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0591: Air Transportation Systems | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Volker Gollnick |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Air transport as part of the global transportation system<br>2. Legal basis of air transportation<br>3. Safety and security aspects<br>4. Aircraft basics<br>5. The role of the aircraft amnufacturer<br>6. The role of the aircraft operator<br>7. Airport operation<br>8. The principles of air traffic management<br>9. Environmental aspects of air transportation |
| **Literature** | 1. V. Gollnick, D. Schmitt: "Air Transport System", Springer-Verlag, ISBN 978-3-7091-1879-5<br>2. H. Mensen: "Handbuch der Luftfahrt", Springer-Verlag, 2003<br>3. J.P. Clark: “Buying the Big Jets”, ISBN 9781317170341 , Taylor & Francis, 2017<br>4. Mike Hirst: The Air Transport System, AIAA, 2008<br>5. D.P. Raymer: "Aircraft Design - A Conceptual Approach", AIAA Education Series, 2006, ISBN 1-56347-281-3<br>6. N. Ashford: "Airport Operations", McGraw-Hill, 1997, ISBN 0-07-003077-4<br>7. P. Maurer: "Luftverkehrsmanagement", Oldenbourg-Verlag, ISBN 3-486-27422-8<br>8. H. Mensen: "Moderne Flugsicherung", Springer-Verlag, 2004, ISBN 3-540-20581-0 |

| Course L0816: Air Transportation Systems | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Volker Gollnick |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M2027: Modeling, Simulation and Optimization (EN)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Modeling, Simulation and Optimization (EN) (L2446) | Integrated Lecture | 4 | 6 |

| | |
|---|---|
| **Module Responsible** | Prof. Benedikt Kriegesmann |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Sound knowledge of engineering mathematics, engineering mechanics and fluid mechanics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students will have an overview of various technical problems and the differential equations, which describe them. Students will gave an overview of different solution approaches and for which kind of problems they can be used for. |
| *Skills* | Students are able to solve different technical problems with the introduced discretization methods. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss problems and jointly develop solution strategies. |
| *Autonomy* | The students are able to develop solution strategies for complex problems self-consistent and critically analyse results. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory<br>Engineering Science: Specialisation Advanced Materials: Compulsory<br>Engineering Science: Specialisation Biomedical Engineering: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering and Management: Compulsory<br>Engineering Science: Specialisation Mechatronics: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Elective Compulsory<br>Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

### Course L2446: Modeling, Simulation and Optimization (EN)

| | |
|---|---|
| **Typ** | Integrated Lecture |
| **Hrs/wk** | 4 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Lecturer** | Prof. Benedikt Kriegesmann, Prof. Alexander Düster, Prof. Robert Seifried, Prof. Thomas Rung |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Partial Differential Equations in technical problems<br>• Overview of modelling approaches<br>• Finite Approximation Methods - Finite Differences / Elements / Volumes<br>• Introduction to the Discrete Element Method<br>• Numerical methods for time dependent problems<br>• Gradient-based optimization |
| **Literature** | Michael Schäfer, Computational Engineering - Introduction to Numerical Methods, Springer. |

# Specialization Materials in Engineering Sciences

In the specialization "materials in engineering", students work mainly with construction materials, modeling materials and nanotechnology and hybrid materials.

## Module M1901: Materials Science Laboratory

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Companion Lecture for Materials Science Laboratory (L1088) | Lecture | 2 | 2 |
| Material Science Laboratory (L1235) | Practical Course | 4 | 4 |

| | |
|---|---|
| **Module Responsible** | Prof. Franziska Lissel |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **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 experiments in the area of materials sciences 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 material sciences to the process of solving practical problems. They identify and overcome typical problems during the realization of experiments in the context of material sciences. |
| **Personal Competence** | |
| *Social Competence* | Students are able to cooperate in small groups in order to conduct experiments in the context of materials sciences. They are able to effectively present and explain their results alone or in groups in front of a qualified audience. |
| *Autonomy* | Students are capable of solving problems in the context of materials sciences 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. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | Reports on each one of the experiments and online learning modules with integrated checking |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory<br>Engineering Science: Specialisation Advanced Materials: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering and Management: Elective Compulsory<br>Mechanical Engineering: Specialisation Product Development and Production: Compulsory<br>Mechanical Engineering: Specialisation Materials in Engineering Sciences: Compulsory<br>Mechanical Engineering - Product Development and Production: Technical Complementary Course Core Studies: Elective Compulsory<br>Product Development, Materials and Production: Technical Complementary Course Core Studies: Elective Compulsory |

| Course L1088: Companion Lecture for Materials Science Laboratory | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Franziska Lissel |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | - Introduction to the Materials Science Laboratory practical course and learning modules;<br>- Collection of data: source of errors and sample distribution;<br>- Error calculation;<br>- Report writing and presentation of results;<br>- Graph plotting using software(s). |
| **Literature** | 1) W.D. Callister, Materials science and engineering: an introduction, Wiley 2000 https://katalog.tub.tuhh.de/Record/270018409 or https://katalog.tub.tuhh.de/Record/1696922097 (online link at 'Exemplare')<br><br>2) John R. Taylor, Fehleranalyse: eine Einführung in die Untersuchung von Unsicherheiten in physikalischen Messungen, 1. Aufl., VCH Verlag, 1988 https://katalog.tub.tuhh.de/Record/027422038 // An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements, 2d Edition, University Science Books, 1997 https://katalog.tub.tuhh.de/Record/024511676 |

| Course L1235: Material Science Laboratory | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 4 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 64, Study Time in Lecture 56 |
| **Lecturer** | Prof. Franziska Lissel, Prof. Alexander Schlaich, Prof. Bodo Fiedler, Prof. Franziska Lissel, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Kaline Pagnan Furlan |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | 5 laboratory experiments:<br><br>- Metals: Tensile test<br><br>- Polymers: Scanning electron microscopy on fracture surfaces of fiber reinforced plastics<br><br>- Polymers: Bending test - bending properties of carbon fiber reinforced plastics<br><br>- Ceramics: Ceramic synthesis - From raw material up to sintered product<br><br>- Ceramics: Mechanical testing - hardness and fracture toughness of ceramic materials |
| **Literature** | 1) Vorlesungsunterlagen Grundlagen der Werkstoffwissenschaft I & II<br><br>2) W.D. Callister, Materials science and engineering: an introduction, Wiley 2000 https://katalog.tub.tuhh.de/Record/270018409 or https://katalog.tub.tuhh.de/Record/1696922097 (online link at 'Exemplare') |

## Module M1005: Enhanced Fundamentals of Materials Science

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Advanced Ceramics and Polymers (EN) (L2983) | Lecture | 2 | 2 |
| Advanced Ceramics and Polymers (EN) (L2984) | Recitation Section (large) | 1 | 1 |
| Materials for Energy Storage and Conversion (DE) (L1086) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Gerold Schneider |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Module "Fundamentals of Materials Science"<br>Module "Materials Science Laboratory"<br>Module "Advanced Materials" |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are able to give an enhanced overview over the following topics in metals, polymers and ceramics: Atomic bonds, crystal and amorphous structures, defects , electrical and mass transport, microstructure and phase diagrams. They are capable to explain the corresponding technical terms. |
| *Skills* | The students are able to apply the appropriate physical and chemical methods for the above mentioned subjects. |
| **Personal Competence** | |
| *Social Competence* | |
| *Autonomy* | The students are capable to understand independently the structure and propeties of ceramics, metals and polymers. They should be able to critally evaluate the profoundness of their knowledge. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | Mechanical Engineering: Specialisation Materials in Engineering Sciences: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

### Course L2983: Advanced Ceramics and Polymers (EN)

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kaline Pagnan Furlan, Prof. Robert Meißner |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | **After the lecture you should be able to (lecture objectives):**<br>• Identify the main characteristics of polymeric and ceramic materials<br>• Understand how to process polymers and ceramics and their applications<br>• Evaluate and select polymers and ceramics according to a prospected application, linking the expected properties and design to an appropriate manufacturing method<br>• Understand about fiber-reinforced composites fabrication, processing, and properties<br>**Polymeric materials**<br>1. Polymers in engineering<br>A brief history of plastics; Why plastics?; Plastics industry; Lightweight construction using plastics.<br>2. Structure of the macromolecule<br>Constitution; chain configuration; chain conformation; potentials; bonds.<br>3. Synthesis, rheology<br>Polymerization; polyaddition; polycondensation; molecular weight and distribution; crosslinking; application temperatures and processing; test methods DSC /DMTA.<br>4. Plastics processing<br>Relationships of viscosity and processing of plastics; The main manufacturing technologies and processing parameters: |

| | |
|---|---|
| | Extrusion, injection molding, calendering, blown films, blow molding, stretch blow molding; Which products can be manufactured with which manufacturing method.<br><br>5. Composite materials<br>Short fiber reinforced and injection molding; fiber types and strength; elastic properties of FRP and anisotropy.<br><br>6. Mechanical properties<br>Understand the material behavior of polymers under mechanical load; know that plastics have a strongly time-dependent deformation behavior and know the reasons; measurement methods to determine the load behavior (tensile test, creep or relaxation test).<br><br>7. Plastics and the environment<br>Understand the advantages and disadvantages of polymers in terms of environmental aspects; know that plastics can be recycled in different ways; know innovative approaches to improve the life cycle assessment.<br><br>**Ceramic materials**<br><br>1. Ceramics in engineering<br>Brief history of ceramic materials; why are ceramic materials used?; relevance of ceramic materials in engineering; overview of common applications.<br><br>2. Ceramic shaping methods<br>Slip casting, tape casting, dip coating, filter pressing, extrusion, injection molding, die and isostatic pressing, robocasting (3D printing).<br><br>3. Sintering<br>Driving force and mechanism of sintering; effect of curved surfaces and diffusion paths; solid state sintering, liquid phase sintering and reaction bonding sintering; sintering stages.<br><br>4. Colloidal science<br>Stability of particles within a solvent; DLVO theory; zeta potential; iso-eletric point; multi-material mixes.<br><br>5. Effect of processing on properties<br>Understand how the different properties of ceramics are affected by the processing parameters during common processing steps.<br><br>6. Ceramic-matrix composites<br>Advantages of ceramic composites; influence of a second phase during sintering; continuous and discontinuous matrix; influence of second phase shape on the mechanical properties; fiber-matrix interfaces.<br>7. Functional properties of ceramics and their applications<br>Structural applications; high-temperature applications; electrical applications; filters and membranes; fuel cells; catalysis; magnetic ceramics; sensors. |
| **Literature** | **Polymeric materials**<br><br>1. Polymeric Materials: Structure, Properties, Applications; G. W. Ehrenstein, Hanser Verlag, ISBN 978-3-446-21461-3 , https://katalog.tub.tuhh.de/Record/319998959<br>2. Polymer Rheology: Fundamentals and Applications; T. A. Osswald and N. Rudolph, Hanser Verlag, ISBN 978-1-56990-517-3 , https://katalog.tub.tuhh.de/Record/793882745<br>3. Rheology of filled polymer systems, A. V. Shenoy, Springer Dodrecht, ISBN 978-0-412-83100-3 , https://katalog.tub.tuhh.de/Record/244182205<br>4. Rheology of Polymeric Systems: Principles and Applications; P. J. Carreau, D. C.R. De Kee and R. P. Chhabra, Hanser Verlag, ISBN 978-1-56990-722-1 , https://doi.org/10.1016/C2018-0-01790-9<br>5. Polymer Testing; W. Grellmann and S. Seidler; Hanser Verlag, ISBN 978-1-56990-549-4 , https://katalog.tub.tuhh.de/Record/527841358<br><br>**Ceramic materials**<br><br>1. D.W. Richerson, Modern ceramic engineering : properties, processing, and use in design, Dekker New York, 1992 https://katalog.tub.tuhh.de/Record/02717039X or https://katalog.tub.tuhh.de/Record/486225119<br>2. A.R. Boccaccini and N.P.Bansal, Ceramics and composites processing methods, John Wiley & Sons 2012 https://katalog.tub.tuhh.de/Record/1679605283 (Chapters 1, 4, 8 and 13)<br>3. R. Riedel and I. Chen, Ceramics Science and Technology, Wiley-VCH, 2011 https://doi.org/10.1002/9783527631957 (Chapters 6, 12 and 16)<br>4. R. Riedel and I. Chen, Ceramics Science and Technology - Volume 4: Applications, Wiley-VCH, 2013 https://doi.org/10.1002/9783527631971 |

| Course L2984: Advanced Ceramics and Polymers (EN) | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Kaline Pagnan Furlan, Prof. Robert Meißner |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | |
| **Literature** | |

| Course L1086: Materials for Energy Storage and Conversion (DE) | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Jörg Weißmüller |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | Advanced understanding of metals:<br>• Physical materials properties<br>o Materials behaviour - elastic, thermal, electrical<br>o Superelasticity and shape memory effect<br>o Fundamentals of electrical conductivity in metals and semiconductors<br>o Superconductivity<br>• Chemical (or "dry") corrosion<br>o Driving forces and mechanisms<br>o Passivation<br>o Growth laws<br>• Introduction to electrochemistry<br>o Electrolytes<br>o Ions<br>o Solvatation<br>o Dissolution and deposition of metals<br>o Galvanic cells and cell voltage<br>o Galvanic series<br>o Nernst equation<br>o Polarizable electrodes<br>o Electrochemical double layer<br>o Capacitive and pseudocapacitive processes<br>o Capacitive currents and Faraday currents<br>• Electrochemical (or "wet") corrosion and corrosion protection<br>o Basic observations<br>o Galvanic corrosion<br>o Protection against galvanic corrosion<br>o Stainless steel<br>o sacrificial anodes<br>o Passivation and Pourbaix diagrams<br>o Corrosion through gas reduction<br>o Crevice corrosion<br>o Stress corrosion cracking<br>o Alloy corrosion and nanoporous metals<br>• Electrochemical energy storage<br>o How a battery works<br>o Lead accumulators<br>o Alkaline batteries<br>o Nickel-metal hydride accumulators<br>o Flux batteries<br>o Lithium-ion accumulators<br>o Electrolytic and super capacitors<br>o Fuel cells<br>• Materials for hydrogen storage<br>o Storage strategies<br>o Requirements for storage materials<br>o State of the art<br>• Magnetism and magnetic materials<br>o Phenomenology: magnetic field and magnetization<br>o Para-, ferro-, antiferromagnets; Curie transition |

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| | o Magnetism at the atomic scale; exchange coupling<br>o Magnetization isotherms, domains<br>o Measurement methods<br>o Magnetocrystalline anisotropy and domain walls<br>o Hard magnetic materials and their applications<br>o Soft magnetic materials and their applications |
| **Literature** | - Vorlesungsskript<br>- W.D. Callister, „Materialwissenschaften und Werkstofftechnik “, Wiley-VCH 2012<br>- Carl H. Hamann, Wolf Vielstich, "Elektrochemie", Wiley-VCH; 4. Auflage 2005<br>- Kurzweil, Dietlmeier, "Elektrochemische Speicher" Springer Vieweg (2015)<br>(eBook: https://link.springer.com/book/10.1007/978-3-658-10900-4 )<br>- B. D. Cullity, C.D. Graham, "Introduction to magnetic materials", John Wiley & Sons, 2011<br>- D. Jiles, "Introduction to magnetism and magnetic materials", CRC press, 2015 |

## Module M1910: Materials Engineering: Materials Selection, Processing and Modelling

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Materials and Process Modeling (L2862) | Lecture | 3 | 3 |
| Materials Selection and Processing (L2861) | Lecture | 3 | 3 |

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|---|---|
| **Module Responsible** | Prof. Norbert Huber |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals of mathematics (differential equations, integration), materials science (classes of materials, structure, properties, tensile test) and engineering mechanics (stress, strain, elasticity, deformation). |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The module deals with the production and properties of engineering materials. Particular attention is paid to material selection, material processing, the associated microstructure and the achievable mechanical properties. In conjunction with the costs, these are decisive for the applicability and economic efficiency. Metallic materials are in the foreground. Ceramics and polymers are also covered in the sense of a broad range of available materials.<br><br>In parallel to the material-technological consideration, the modeling of material behavior by means of phenomenological material laws for plasticity under monotonic and cyclic loading is worked out. In addition to the evaluation of component behavior, plasticity also plays a major role in manufacturing processes and thus provides the basis for process simulation. Process models and simulation methods for selected manufacturing processes, such as rolling or forming, are presented for this topic area. |
| *Skills* | Students are able to<br>• analyze the material behavior of metallic materials for general load histories with respect to elasticity and plasticity as well as the associated velocity-dependent material behavior and describe it with corresponding material laws<br>• to relate the deformation behavior to the underlying microstructural mechanisms<br>• to assess how processing procedures affect the chain microstructure - process - properties<br>• understand how the mechanical properties of metallic materials can be tailored by the processing due to microstructural design |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>• actively enrich and shape the course by contributing to the discussion.<br>• develop solutions to given problems and explain them in English in the plenum and discuss them with their fellow students. |
| *Autonomy* | Students are able to,<br>• assess their own strengths and weaknesses<br>• concretely assess their respective learning status and define further work steps on this basis<br>• abstract given tasks and then apply them to new problems by transferring the taught material. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |

**Course achievement**

| Compulsory | Bonus | Form | Description |
|---|---|---|---|
| No | 20 % | Excercises | Wir stellen Übungsaufgaben (ÜA), die während des Semesters erbracht und in den wöchentlichen Übungen vorgestellt werden. Diese können im Umfang von bis zu 20% bei der Prüfung berücksichtigt werden. |

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| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory<br>Engineering Science: Specialisation Advanced Materials: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering and Management: Elective Compulsory<br>Mechanical Engineering: Specialisation Materials in Engineering Sciences: Compulsory |

| Course L2862: Materials and Process Modeling | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Norbert Huber |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | 1. Relevance of plasticity in materials processing and operation<br>2. Fundamentals of plasticity in metals and alloys<br>3. Modellierung von Materialverhalten<br>4. Plasticity in cyclic loading<br>5. Rate dependency, recristallization<br>6. Rolling, forming, and solid state joining processes<br>7. Residual stress design |
| **Literature** | • Hull and Bacon: Introduction to Dislocations (1984)<br>• G. Gottstein: Physik. Grundlagen der Materialk. (2001)<br>• P. Haupt: Cont. Mechanics and Theory of Materials (2002)<br>• N. Huber: Vorlesungsskript „Grundlagen der mechanischen Eigenschaften von Werkstoffen“, TUHH |

| Course L2861: Materials Selection and Processing | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Kaline Pagnan Furlan |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | 1. Introduction<br>2. Overview of fabrication processes<br>3. Shape considerations: macrostructural aspects<br>4. Material properties: microstructural aspects<br>5. Materials engineering: microstructure, shape and processing relation<br>6. Materials engineering: function and costs relation |
| **Literature** | 1. K.P. Furlan, Lecture slides “Materials Selection and Processing (lv2861)”, StudIP E-learning system, TUHH<br>2. W.D. Callister, Materials science and engineering: an introduction, 5 th edition, Wiley (2000) https://katalog.tub.tuhh.de/Record/270018409 or https://katalog.tub.tuhh.de/Record/1696922097 (online link at ‘Exemplare’)<br>3. M.F.Ashby, Materials selection in mechanical design, 3 rd edition, Butterworth-Heinemann (2005) https://katalog.tub.tuhh.de/Record/39697838X |

# Specialization Mechatronics

In the specialization "Mechatronics" students learn to combine the mechanical engineering content with the knowledge and skills of electrical engineering, to study in mechatronics, those sub-disciplines and related disciplines problems that arise.

## 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/Python 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/Python,<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 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory<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 Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Data Science: Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Elective Compulsory<br>Engineering Science: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory |

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|---|---|
| | Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective 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 |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | 1. Finite precision arithmetic, error analysis, conditioning and stability<br>2. Linear systems of equations: LU and Cholesky factorization, condition<br>3. Interpolation: polynomial, spline and trigonometric interpolation<br>4. Nonlinear equations: fixed point iteration, root finding algorithms, Newton's method<br>5. Linear and nonlinear least squares problems: normal equations, Gram Schmidt and Householder orthogonalization, singular value decomposition, regularizatio, Gauss-Newton and Levenberg-Marquardt methods<br>6. Eigenvalue problems: power iteration, inverse iteration, QR algorithm<br>7. Numerical differentiation<br>8. Numerical integration: Newton-Cotes rules, error estimates, Gauss quadrature, adaptive quadrature |
| **Literature** | • Gander/Gander/Kwok: Scientific Computing: An introduction using Maple and MATLAB, Springer (2014)<br>• 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. Jens-Peter Zemke |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0777: Semiconductor Circuit Design

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Prof. Qiang Li |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals of electrical engineering<br><br>Basics of physics, especially semiconductor physics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence**<br>*Knowledge* | • Students are able to explain the functionality of different MOS devices in electronic circuits.<br>• Students are able to explain how analog circuits functions and where they are applied.<br>• Students are able to explain the functionality of fundamental operational amplifiers and their specifications.<br>• Students know the fundamental digital logic circuits and can discuss their advantages and disadvantages.<br>• Students have knowledge about memory circuits and can explain their functionality and specifications.<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**<br>*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 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Compulsory<br>Engineering Science: Specialisation Electrical Engineering: Compulsory<br>Engineering Science: Specialisation Mechatronics: Elective Compulsory<br>Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Compulsory<br>Mechatronics: Specialisation Electrical Systems: Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: 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. Qiang Li |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | • Repetition Semiconductorphysics and Diodes<br>• Functionality and characteristic curve of bipolar transistors<br>• Basic circuits with bipolar transistors<br>• Functionality and characteristic curve of MOS transistors<br>• Basic circuits with MOS transistors for amplifiers<br>• Operational amplifiers and their applications<br>• Typical applications for analog and digital circuits<br>• Realization of logical functions<br>• Basic circuits with MOS transistors for combinational logic<br>• Memory circuits<br>• Basic circuits with MOS transistors for sequential logic<br>• Basic concepts of analog-to-digital and digital-to-analog-converters |
| **Literature** | U. Tietze und Ch. Schenk, E. Gamm, Halbleiterschaltungstechnik, Springer Verlag, 14. Auflage, 2012, ISBN 3540428496<br><br>R. J. Baker, CMOS - Circuit Design, Layout and Simulation, J. Wiley & Sons Inc., 3. Auflage, 2011, ISBN: 047170055S<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. Qiang Li, Weitere Mitarbeiter |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | • Basic circuits and characteristic curves of bipolar transistors<br>• Basic circuits and characteristic curves of MOS transistors for amplifiers<br>• Realization and dimensioning of operational amplifiers<br>• Realization of logic functions<br>• Basic circuits with MOS transistors for combinational and sequential logic<br>• Memory circuits<br>• Circuits for analog-to-digital and digital-to-analog converters<br>• Design of exemplary circuits |
| **Literature** | U. Tietze und Ch. Schenk, E. Gamm, Halbleiterschaltungstechnik, Springer Verlag, 14. Auflage, 2012, ISBN 3540428496<br><br>R. J. Baker, CMOS - Circuit Design, Layout and Simulation, J. Wiley & Sons Inc., 3. Auflage, 2011, ISBN: 047170055S<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 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.<br><br>The students are familiar with the contents of lecture and tutorials. They can explain and apply them to new problems. |
| *Skills* | The students are able to describe and analyse deterministic signals and linear time-invariant systems using methods of signal and system theory. They can analyse and design basic systems regarding important properties such as magnitude and phase response, stability, linearity etc.. They can assess the impact of LTI systems on the signal properties in time and frequency domain. |
| **Personal Competence** | |
| *Social Competence* | The students can jointly solve specific problems. |
| *Autonomy* | The students are able to acquire relevant information from appropriate literature sources. They can control their level of knowledge during the lecture period by solving tutorial problems, software tools, clicker system. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Core Qualification: Compulsory<br>Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory<br>Data Science: Specialisation I. Mathematics/Computer Science: Elective Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Compulsory<br>Computer Science in Engineering: Core Qualification: Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Elective 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** | • Introduction to signal and system theory<br>• Signals<br>  ◦ Classification of signals<br>  ▪ Continuous-time and discrete-time signals<br>  ▪ Analog and digital signals<br>  ▪ Deterministic and random signals<br>  ◦ Description of LTI systems by differential equations or difference equations, respectively<br>  ◦ Basic properties of signals and operations on signals<br>  ◦ Elementary signals<br>  ◦ Distributions (Generalized Functions)<br>  ◦ Power and energy of signals<br>  ◦ Correlation functions of deterministic signals<br>  ▪ Autocorrelation function |

| | |
|---|---|
| | ▪ Crosscorrelation function<br>▪ Orthogonal signals<br>▪ Applications of correlation<br>• Linear time-invariant (LTI) systems<br>◦ Linearity<br>◦ Time-invariance<br>◦ Description of LTI systems by impulse response and frequency response<br>◦ Convolution<br>◦ Convolution and correlation<br>◦ Properties of LTI-systems<br>◦ Causal systems<br>◦ Stable systems<br>◦ Memoryless systems<br>• Fourier Series and Fourier Transform<br>◦ Fourier transform of continuous-time signals, discrete-time signals, periodic signals, non-periodic signals<br>◦ Properties of the Fourier transform<br>◦ Fourier transform of some basic signals<br>◦ Parseval’s theorem<br>• Analysis of LTI-systems and signals in the frequency domain<br>◦ Frequency response, magnitude response and phase response<br>◦ Transmission factor, attenuation, gain<br>◦ Frequency-flat and frequency-selective LTI-systems<br>◦ Bandwidth definitions<br>◦ Basic types of systems (filters), lowpass, highpass, bandpass, bandstop systems<br>◦ Phase delay and group delay<br>◦ Linear-phase systems<br>◦ Distortion-free systems<br>◦ Spectrum analysis with limited observation window: Leakage effect<br>• Laplace Transform<br>◦ Relation of Fourier transform and Laplace transform<br>◦ Properties of the Laplace transform<br>◦ Laplace transform of some basic signals<br>• Analysis of LTI-systems in the s-domain<br>◦ Transfer function of LTI-systems<br>◦ Relation of Laplace transform, magnitude response and phase response<br>◦ Analysis of LTI-systems using pole-zero plots<br>◦ Allpass filters<br>◦ Minimum-phase, maximum-phase and mixed phase filters<br>◦ Stable systems<br>• Sampling<br>◦ Sampling theorem<br>◦ Reconstruction of continuous-time signals in frequency domain and time domain<br>◦ Oversampling<br>◦ Aliasing<br>◦ Sampling with pulses of finite duration, sample and hold<br>◦ Decimation and interpolation<br>• Discrete-Time Fourier Transform (DTFT)<br>◦ Relation of Fourier transform and DTFT<br>◦ Properties of the DTFT<br>• Discrete Fourier Transform (DFT)<br>◦ Relation of DTFT and DFT<br>◦ Cyclic properties of the DFT<br>◦ DFT matrix<br>◦ Zero padding<br>◦ Cyclic convolution<br>◦ Fast Fourier Transform (FFT)<br>◦ Application of the DFT: Orthogonal Frequency Division Multiplex (OFDM)<br>• Z-Transform<br>◦ Relation of Laplace transform, DTFT, and z-transform<br>◦ Properties of the z-transform<br>◦ Z-transform of some basic discrete-time signals<br>• Discrete-time systems, digital filters<br>◦ FIR and IIR filters<br>◦ Z-transform of digital filters<br>◦ Analysis of discrete-time systems using pole-zero plots in the z-domain<br>◦ Stability<br>◦ Allpass filters<br>◦ Minimum-phase, maximum-phase and mixed-phase filters<br>◦ Linear phase 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 M2027: Modeling, Simulation and Optimization (EN)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Modeling, Simulation and Optimization (EN) (L2446) | Integrated Lecture | 4 | 6 |

| | |
|---|---|
| **Module Responsible** | Prof. Benedikt Kriegesmann |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Sound knowledge of engineering mathematics, engineering mechanics and fluid mechanics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students will have an overview of various technical problems and the differential equations, which describe them. Students will gave an overview of different solution approaches and for which kind of problems they can be used for. |
| *Skills* | Students are able to solve different technical problems with the introduced discretization methods. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss problems and jointly develop solution strategies. |
| *Autonomy* | The students are able to develop solution strategies for complex problems self-consistent and critically analyse results. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory<br>Engineering Science: Specialisation Advanced Materials: Compulsory<br>Engineering Science: Specialisation Biomedical Engineering: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering and Management: Compulsory<br>Engineering Science: Specialisation Mechatronics: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Elective Compulsory<br>Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

### Course L2446: Modeling, Simulation and Optimization (EN)

| | |
|---|---|
| **Typ** | Integrated Lecture |
| **Hrs/wk** | 4 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Lecturer** | Prof. Benedikt Kriegesmann, Prof. Alexander Düster, Prof. Robert Seifried, Prof. Thomas Rung |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Partial Differential Equations in technical problems<br>• Overview of modelling approaches<br>• Finite Approximation Methods - Finite Differences / Elements / Volumes<br>• Introduction to the Discrete Element Method<br>• Numerical methods for time dependent problems<br>• Gradient-based optimization |
| **Literature** | Michael Schäfer, Computational Engineering - Introduction to Numerical Methods, Springer. |

## Module M0854: Mathematics IV

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Prof. Marko Lindner |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mathematics I - III |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can name the basic concepts in Mathematics IV. They are able to explain them using appropriate examples.<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. |
| **Workload in Hours** | Independent Study Time 68, Study Time in Lecture 112 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min (Complex Functions) + 60 min (Differential Equations 2) |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Computational Engineering: Elective Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Compulsory<br>Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Elective 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** | Dr. Hanna Peywand Kiani |
| **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 |

# Specialization Product Development and Production

The specialization "Product Development and Production" maps the product creation process from strategic product planning, through the systematic and methodical development of products, including concept development, design, material selection, simulation and test to production, the planning and control and the use of modern manufacturing processes, to high-performance materials.

## Module M0726: Production Technology

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of Machine Tools (L0689) | Lecture | 2 | 2 |
| Fundamentals of Machine Tools (L1992) | Recitation Section (large) | 1 | 1 |
| Forming and Cutting Technology (L0613) | Lecture | 2 | 2 |
| Forming and Cutting Technology (L0614) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Jan Hendrik Dege |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | without major course assessment<br><br>internship recommended<br><br>Previous knowledge in mathematics, mechanics and electrical engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to ...<br><br>• explain the basics of chip formation and mechanisms and models of machining.<br>• explain methods and parameters for design and analysis of metal forming, machining processes and tools.<br>• explain technical concepts of machine tool building and give an overview on trends in the machine tool industry.<br>• explain types, constructions and functions of CNC-machines and give an overview on multi-machine systems.<br>• explain equipment components. |
| *Skills* | Students are able to...<br><br>• select tool geometry, cutting materials, process parameters and appropriate measuring technique in accordance with the requirements.<br>• estimate occurring forces and temperatures during chip formation.<br>• select appropriate machine tools for machining and create NC programs for turning and milling.<br>• assess the quality of a machine tools and to detect weak points. |
| **Personal Competence** | |
| *Social Competence* | Students are able to ...<br><br>• develop solutions in a production environment with qualified personnel at technical level and represent decisions. |
| *Autonomy* | Students are able to ...<br><br>• interpret independently cutting processes.<br>• create independently NC programs.<br>• select independently machine tools by reference to appropriate requirements.<br>• assess own strengths and weaknesses in general.<br>• assess their learning progress and define gaps to be improved.<br>• assess possible consequences of their actions. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering and Management: Elective Compulsory<br>Mechanical Engineering: Specialisation Product Development and Production: Compulsory<br>Mechanical Engineering - Product Development and Production: Technical Complementary Course Core Studies: Elective Compulsory<br>Mechatronics: Specialisation Robot- and Machine-Systems: Elective Compulsory<br>Product Development, Materials and Production: Technical Complementary Course Core Studies: Elective Compulsory |

| Course L0689: Fundamentals of Machine Tools | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thorsten Schüppstuhl |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Terminology and trends in machine tool building<br><br>CNC controls<br><br>NC programming and NC programming systems<br><br>Types, construction and function of CNC machines<br><br>Multi-machinesystems<br><br>Equipmentcomponents for machine tools<br><br>Assessment of machine tools |
| **Literature** | *Conrad, K.J*<br><br>*Taschenbuch der Werkzeugmaschinen*<br><br>*9783446406414*<br><br>*Fachbuchverlag 2006*<br><br><br>*Perović, Božina*<br><br>*Spanende Werkzeugmaschinen - Ausführungsformen und Vergleichstabellen*<br><br>*ISBN: 3540899529*<br><br>*Berlin [u.a.]: Springer, 2009*<br><br><br>*Weck, Manfred*<br><br>*Werkzeugmaschinen 1 - Maschinenarten und Anwendungsbereiche*<br><br>*ISBN: 9783540225041*<br><br>*Berlin [u.a.]: Springer, 2005*<br><br><br>*Weck, Manfred; Brecher, Christian*<br><br>*Werkzeugmaschinen 4 - Automatisierung von Maschinen und Anlagen*<br><br>*ISBN: 3540225072*<br><br>*Berlin [u.a.]: Springer, 2006*<br><br><br>*Weck, Manfred; Brecher, Christian*<br><br>*Werkzeugmaschinen 5 - Messtechnische Untersuchung und Beurteilung, dynamische Stabilität*<br><br>*ISBN: 3540225056*<br><br>*Berlin [u.a.]: Springer, 2006* |

| Course L1992: Fundamentals of Machine Tools | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Thorsten Schüppstuhl |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0613: Forming and Cutting Technology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Jan Hendrik Dege |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Thermomechanical Principles and Models of Machining<br>• Chip Formation, Forces, Temperature and Tribology process<br>• Wear mechanisms and wear patterns<br>• Machinability by Cutting and Forming, Specific Problems of Light Weight Structures<br>• Cutting Material and Coatings<br>• Methods and Parameters for Analysis and Configuration of Forming and Cutting Processes and Tools |
| **Literature** | Lange, K.; Umformtechnik Grundlagen, 2. Auflage, Springer (2002)<br><br>Tönshoff, H.; Spanen Grundlagen, 2. Auflage, Springer Verlag (2004)<br><br>König, W., Klocke, F.; Fertigungsverfahren Bd. 4 *Massivumformung*, 4. Auflage, VDI-Verlag (1996)<br><br>König, W., Klocke, F.; Fertigungsverfahren Bd. 5 *Blechbearbeitung*, 3. Auflage, VDI-Verlag (1995)<br><br>Klocke, F., König, W.; Fertigungsverfahren *Schleifen, Honen, Läppen*, 4. Auflage, Springer Verlag (2005)<br><br>König, W., Klocke, F.: Fertigungsverfahren *Drehen, Fräsen, Bohren,* 7. Auflage, Springer Verlag (2002) |

| Course L0614: Forming and Cutting Technology | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Jan Hendrik Dege |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1901: Materials Science Laboratory

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Companion Lecture for Materials Science Laboratory (L1088) | Lecture | 2 | 2 |
| Material Science Laboratory (L1235) | Practical Course | 4 | 4 |

| | |
|---|---|
| **Module Responsible** | Prof. Franziska Lissel |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **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 experiments in the area of materials sciences 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 material sciences to the process of solving practical problems. They identify and overcome typical problems during the realization of experiments in the context of material sciences. |
| **Personal Competence** | |
| *Social Competence* | Students are able to cooperate in small groups in order to conduct experiments in the context of materials sciences. They are able to effectively present and explain their results alone or in groups in front of a qualified audience. |
| *Autonomy* | Students are capable of solving problems in the context of materials sciences 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. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | Reports on each one of the experiments and online learning modules with integrated checking |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory<br>Engineering Science: Specialisation Advanced Materials: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering and Management: Elective Compulsory<br>Mechanical Engineering: Specialisation Product Development and Production: Compulsory<br>Mechanical Engineering: Specialisation Materials in Engineering Sciences: Compulsory<br>Mechanical Engineering - Product Development and Production: Technical Complementary Course Core Studies: Elective Compulsory<br>Product Development, Materials and Production: Technical Complementary Course Core Studies: Elective Compulsory |

### Course L1088: Companion Lecture for Materials Science Laboratory

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Franziska Lissel |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | - Introduction to the Materials Science Laboratory practical course and learning modules;<br>- Collection of data: source of errors and sample distribution;<br>- Error calculation;<br>- Report writing and presentation of results;<br>- Graph plotting using software(s). |
| **Literature** | 1) W.D. Callister, Materials science and engineering: an introduction, Wiley 2000 https://katalog.tub.tuhh.de/Record/270018409 or https://katalog.tub.tuhh.de/Record/1696922097 (online link at 'Exemplare')<br><br>2) John R. Taylor, Fehleranalyse: eine Einführung in die Untersuchung von Unsicherheiten in physikalischen Messungen, 1. Aufl., VCH Verlag, 1988 https://katalog.tub.tuhh.de/Record/027422038 // An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements, 2d Edition, University Science Books, 1997 https://katalog.tub.tuhh.de/Record/024511676 |

| Course L1235: Material Science Laboratory | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 4 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 64, Study Time in Lecture 56 |
| **Lecturer** | Prof. Franziska Lissel, Prof. Alexander Schlaich, Prof. Bodo Fiedler, Prof. Franziska Lissel, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Kaline Pagnan Furlan |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | 5 laboratory experiments:<br>- Metals: Tensile test<br>- Polymers: Scanning electron microscopy on fracture surfaces of fiber reinforced plastics<br>- Polymers: Bending test - bending properties of carbon fiber reinforced plastics<br>- Ceramics: Ceramic synthesis - From raw material up to sintered product<br>- Ceramics: Mechanical testing - hardness and fracture toughness of ceramic materials |
| **Literature** | 1) Vorlesungsunterlagen Grundlagen der Werkstoffwissenschaft I & II<br>2) W.D. Callister, Materials science and engineering: an introduction, Wiley 2000 https://katalog.tub.tuhh.de/Record/270018409 or https://katalog.tub.tuhh.de/Record/1696922097 (online link at ‘Exemplare’) |

## Module M0599: Digital Product Development and Lightweight Design

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| CAE-Team Project (L0271) | Project-/problem-based Learning | 2 | 2 |
| Digital Product Development (L0269) | Lecture | 2 | 2 |
| Development of Lightweight Design Products (L0270) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Dieter Krause |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Advanced Knowledge about engineering design:<br>Fundamentals of Mechanical Engineering Design<br>Mechanical Engineering: Design<br>Advanced Mechanical Engineering Design |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After completing the module, students are capable of:<br>• explaining the functional principle of 3D-CAD-Systems, PDM- and FEM-Systems<br>• describing the interaction of the different CAE-Systems in the product development process |
| *Skills* | After completing the module, students are able to:<br>• evaluate different CAD- and PDM-Systems with regards to the desired requirements such as classification schemes and product structuring<br>• design an exemplary product using CAD-,PDM- and/or FEM-Systems with shared workload |
| **Personal Competence** | |
| *Social Competence* | After completing the module, students are able to:<br>• To develop a project plan and allocate work appropriate work packages in the framework of group discussions<br>• Present project results as a team for instance in a presentation |
| *Autonomy* | Students are capable of:<br>• independently adapt to a CAE-Tool and complete a given practical task with it |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: Yes; Bonus: 20 %; Form: Subject theoretical and practical work; Description: CAE-Teamprojekt inkl. Vortrag und Ausarbeitung |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 |
| **Assignment for the Following Curricula** | 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 Product Development and Production: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory<br>Mechanical Engineering: Specialisation Product Development and Production: Compulsory<br>Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory<br>Mechanical Engineering - Product Development and Production: Technical Complementary Course Core Studies: Elective Compulsory<br>Product Development, Materials and Production: Technical Complementary Course Core Studies: Elective Compulsory |

| Course L0271: CAE-Team Project | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Practical Introduction in the used software systems (Creo, Windchill, Hyperworks)<br>• Team formation, allocation of tasks and generation of a project plan<br>• Collective creation of one product out of CAD models supported by FEM calculations and PDM system<br>• Manufacturing of selected parts using 3D printer<br>• Presentation of results<br><br>**Description**<br><br>Part of the module is a project based team orientated practical course using the PBL method. In this course, students learn the handling of modern CAD, PDM and FEM systems (Creo, Windchill and Hyperworks). After a short introduction in the applied software systems, students work in teams on a task during the semester. The aim is the development of one product out of several CAD parts models using a PDM system including FEM calculations of selected parts and 3D printing of parts. The developed product must be presented in a joint presentation. |
| **Literature** | • Ehrlenspiel, K.: Integrierte Produktentwicklung, München, Carl Hanser Verlag<br>• Lee, K.: Principles of CAD / CAM / CAE Systems, Addison Wesles<br>• Schichtel, M.: Produktdatenmodellierung in der Praxis, München, Carl Hanser Verlag<br>• Anderl, R.: CAD Schnittstellen, München, Carl Hanser Verlag<br>• Spur, G., Krause, F.: Das virtuelle Produkt, München, Carl Hanser Verlag |

| Course L0269: Digital Product Development | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Introduction to Integrated Product Development<br>• 3D CAD -Systems and CAD interfaces<br>• Administration of part lists / PDM systems<br>• PDM in different industries<br>• Selection of CAD-/PDM Systems<br>• Simulation<br>• Construction methods<br>• Design for X |
| **Literature** | • Ehrlenspiel, K.: Integrierte Produktentwicklung, München, Carl Hanser Verlag<br>• Lee, K.: Principles of CAD / CAM / CAE Systems, Addison Wesles<br>• Schichtel, M.: Produktdatenmodellierung in der Praxis, München, Carl Hanser Verlag<br>• Anderl, R.: CAD Schnittstellen, München, Carl Hanser Verlag<br>• Spur, G., Krause, F.: Das virtuelle Produkt, München, Carl Hanser Verlag |

| Course L0270: Development of Lightweight Design Products | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause, Prof. Benedikt Kriegesmann |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Lightweight design materials<br>• Product development process for lightweight structures<br>• Dimensioning of lightweight structures |
| **Literature** | • Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, 2005.<br>• Klein, B., „Leichtbau-Konstruktion", Vieweg & Sohn, Braunschweig, 1989.<br>• Krause, D., „Leichtbau”, In: Handbuch Konstruktion, Hrsg.: Rieg, F., Steinhilper, R., München, Carl Hanser Verlag, 2012.<br>• Schulte, K., Fiedler, B., „Structure and Properties of Composite Materials”, Hamburg, TUHH - TuTech Innovation GmbH, 2005.<br>• Wiedemann, J., „Leichtbau Band 1: Elemente“, Springer, Berlin, Heidelberg, 1986. |

# Specialization Theoretical Mechanical Engineering

The focus of the specialization "Theoretical Mechanical Engineering" lies on theory-method-oriented content and principles as well as intensive scientific thinking training. The students enter a wide-open field of work, especially in the area of mechanical and automotive engineering, biotechnology and medical technology, power engineering, aerospace engineering, shipbuilding, automation technology, materials science and related fields.

## 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/Python 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/Python,<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 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory<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 Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Data Science: Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory<br>Data Science: Core Qualification: Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Elective Compulsory<br>Engineering Science: Core Qualification: Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory |

| | |
|---|---|
| | Computer Science in Engineering: Core Qualification: Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective 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 |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | 1. Finite precision arithmetic, error analysis, conditioning and stability<br>2. Linear systems of equations: LU and Cholesky factorization, condition<br>3. Interpolation: polynomial, spline and trigonometric interpolation<br>4. Nonlinear equations: fixed point iteration, root finding algorithms, Newton's method<br>5. Linear and nonlinear least squares problems: normal equations, Gram Schmidt and Householder orthogonalization, singular value decomposition, regularizatio, Gauss-Newton and Levenberg-Marquardt methods<br>6. Eigenvalue problems: power iteration, inverse iteration, QR algorithm<br>7. Numerical differentiation<br>8. Numerical integration: Newton-Cotes rules, error estimates, Gauss quadrature, adaptive quadrature |
| **Literature** | • Gander/Gander/Kwok: Scientific Computing: An introduction using Maple and MATLAB, Springer (2014)<br>• 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. Jens-Peter Zemke |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0854: Mathematics IV

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Prof. Marko Lindner |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mathematics I - III |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can name the basic concepts in Mathematics IV. They are able to explain them using appropriate examples.<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. |
| **Workload in Hours** | Independent Study Time 68, Study Time in Lecture 112 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min (Complex Functions) + 60 min (Differential Equations 2) |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Computational Engineering: Elective Compulsory<br>Electrical Engineering: Core Qualification: Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Compulsory<br>Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Elective 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** | Dr. Hanna Peywand Kiani |
| **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 M2027: Modeling, Simulation and Optimization (EN)

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Modeling, Simulation and Optimization (EN) (L2446) | Integrated Lecture | 4 | 6 |

| | |
|---|---|
| **Module Responsible** | Prof. Benedikt Kriegesmann |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Sound knowledge of engineering mathematics, engineering mechanics and fluid mechanics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students will have an overview of various technical problems and the differential equations, which describe them. Students will gave an overview of different solution approaches and for which kind of problems they can be used for. |
| *Skills* | Students are able to solve different technical problems with the introduced discretization methods. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss problems and jointly develop solution strategies. |
| *Autonomy* | The students are able to develop solution strategies for complex problems self-consistent and critically analyse results. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory<br>Engineering Science: Specialisation Advanced Materials: Compulsory<br>Engineering Science: Specialisation Biomedical Engineering: Compulsory<br>Engineering Science: Specialisation Mechanical Engineering and Management: Compulsory<br>Engineering Science: Specialisation Mechatronics: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory<br>Mechanical Engineering: Specialisation Mechatronics: Elective Compulsory<br>Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

### Course L2446: Modeling, Simulation and Optimization (EN)

| | |
|---|---|
| **Typ** | Integrated Lecture |
| **Hrs/wk** | 4 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Lecturer** | Prof. Benedikt Kriegesmann, Prof. Alexander Düster, Prof. Robert Seifried, Prof. Thomas Rung |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Partial Differential Equations in technical problems<br>• Overview of modelling approaches<br>• Finite Approximation Methods - Finite Differences / Elements / Volumes<br>• Introduction to the Discrete Element Method<br>• Numerical methods for time dependent problems<br>• Gradient-based optimization |
| **Literature** | Michael Schäfer, Computational Engineering - Introduction to Numerical Methods, Springer. |

## Module M2064: Introduction to Machine Learning for Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Introduction to Machine Learning for Engineering (L3333) | Lecture | 2 | 4 |
| Introduction to Machine Learning for Engineering (L3332) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Timm Faulwasser |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Linear algebra, differentiation of vector-valued functions, basic programming |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students learn basic techniques of Machine Learning. They he basic of selected ML techniques such as KNN, support vector macheines, Gaussian process and kernel regression. They are alos familar with neural network and their training |
| *Skills* | The students are able to decide whether given learning tasks from engineering are classification or regression problems. They know essenetial differences between unsupervised, supervised and reinforcement learning. They can formalize nonlinear programming problems via KKT conditions. They can apply basic concepts from statistics and stochastics. They can apply the following to simple problems: KNN, support vector macheines, Gaussian process and kernel regression and artificial neural networks. |
| **Personal Competence** | |
| *Social Competence* | The students can collaborate across boundaries of disciplines and in international teams. |
| *Autonomy* | The student can formulate questions and problems with respect to complex issues. They can program selected techniques on their own in Python. |
| **Workload in Hours** | Independent Study Time 138, Study Time in Lecture 42 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: No; Bonus: 20 %; Form: Midterm; Description: |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Elective Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory<br>Engineering Science: Specialisation Mechatronics: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering and Management: Elective Compulsory<br>Engineering Science: Specialisation Electrical Engineering: Elective Compulsory<br>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Elective Compulsory<br>Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

### Course L3333: Introduction to Machine Learning for Engineering

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Timm Faulwasser |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L3332: Introduction to Machine Learning for Engineering | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Timm Faulwasser |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See modul description. |
| **Literature** | |

## Module M2063: Introduction to Optimal and Model Predictive Control

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Introduction to Optimal and Model Predictive Control (L3331) | Lecture | 2 | 4 |
| Introduction to Optimal and Model Predictive Control (L3330) | Recitation Section (small) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Timm Faulwasser |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Linear algebra, differentiation of vector-valued functions, basic programming, if possible: basic of control engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | In the lecture, students learn the basic techniques of optimal and predictive control for linear systems. In particular, the linear quadratic state controller and the basics of dynamic programming are discussed. The basic idea of model predictive control for linear systems with quadratic cost functionals is also discussed, and the question of stability is discussed. The students also learn how the problems that arise can be solved using numerical algorithms. |
| *Skills* | The students are able to design simple optimal state feedback for linear systems. You can formulate discrete-time optimal control problems and solve them using numerical methods. They can formulate and solve dynamic programming recursion for linear systems. The students can formulate simple MPC controllers and implement numerical ones. They can also make statements about the nominal stability of the designed control closed-loop. |
| **Personal Competence** | |
| *Social Competence* | The students can collaborate across boundaries of disciplines and in international teams. |
| *Autonomy* | The student can formulate questions and problems with respect to complex issues. They can program selected techniques on their own in Matlab or Python. |
| **Workload in Hours** | Independent Study Time 138, Study Time in Lecture 42 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory<br>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory<br>Electrical Engineering: Core Qualification: Elective Compulsory<br>Electrical Engineering and Information Technology: Core Qualification: Elective Compulsory<br>Engineering Science: Specialisation Mechatronics: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory<br>Engineering Science: Specialisation Electrical Engineering: Elective Compulsory<br>Engineering Science: Specialisation Mechanical Engineering and Management: Elective Compulsory<br>Aeronautics: Core Qualification: Elective Compulsory<br>Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory |

### Course L3331: Introduction to Optimal and Model Predictive Control

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Timm Faulwasser, Prof. Annika Eichler |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L3330: Introduction to Optimal and Model Predictive Control | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Timm Faulwasser, Prof. Annika Eichler |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See modul description |
| **Literature** | Will be announced at the beginning of the course. |

# Thesis

The work at the Bachelor thesis should show that the nominee or candidate is able to work on a problem from her or his field independently with scientific methods within an intended term.

## 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>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. |
| **Workload in Hours** | Independent Study Time 360, Study Time in Lecture 0 |
| **Credit points** | 12 |
| **Course achievement** | None |
| **Examination** | Thesis |
| **Examination duration and scale** | According to General Regulations |
| **Assignment for the Following Curricula** | General Engineering Science (German program): Thesis: Compulsory<br>General Engineering Science (German program, 7 semester): Thesis: Compulsory<br>Civil- and Environmental Engineering: Thesis: Compulsory<br>Bioprocess Engineering: Thesis: Compulsory<br>Chemical and Bioprocess Engineering: Thesis: Compulsory<br>Computer Science: Thesis: Compulsory<br>Data Science: Thesis: Compulsory<br>Electrical Engineering: Thesis: Compulsory<br>Electrical Engineering and Information Technology: Thesis: Compulsory<br>Engineering Science: Thesis: Compulsory<br>General Engineering Science (English program): Thesis: Compulsory<br>General Engineering Science (English program, 7 semester): Thesis: Compulsory<br>Green Technologies: Energy, Water, Climate: Thesis: Compulsory<br>Computer Science in Engineering: Thesis: Compulsory<br>Logistics and Mobility: Thesis: Compulsory<br>Mechanical Engineering: Thesis: Compulsory<br>Mechatronics: Thesis: Compulsory |

| | |
|---|---|
| | Naval Architecture: Thesis: Compulsory<br>Technomathematics: Thesis: Compulsory<br>Teilstudiengang Lehramt Metalltechnik: Thesis: Compulsory<br>Process Engineering: Thesis: Compulsory<br>Engineering and Management - Major in Logistics and Mobility: Thesis: Compulsory |