TUHH
Hamburg
University of
Technology

Module Manual

Bachelor of Science (B.Sc.)

Mechanical Engineering

Cohort: Winter Term 2022

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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 M1692: Computer Science for Engineers - Introduction and Overview

Courses

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

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

Course L2685: Computer Science for Engineers - Introduction and Overview

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

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

Course L2686: Computer Science for Engineers - Introduction and Overview

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

Module 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. Wolfgang Hintze
Admission Requirements	None
Recommended Previous Knowledge	no course assessments required internship recommended
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to ... • name basic criteria for the selection of manufacturing processes. • name the main groups of Manufacturing Technology. • name the application areas of different manufacturing processes. • name boundaries, advantages and disadvantages of the different manufacturing process. • describe elements, geometric properties and kinematic variables and requirements for tools, workpiece and process. • explain the essential models of manufacturing technology.
Skills	Students are able to... • select manufacturing processes in accordance with the requirements. • design manufacturing processes for simple tasks to meet the required tolerances of the component to be produced. • assess components in terms of their production-oriented construction.
Personal Competence	
Social Competence	Students are able to ... • develop solutions in a production environment with qualified personnel at technical level and represent decisions.
Autonomy	Students are able to .. • interpret independently the manufacturing process. • assess own strengths and weaknesses in general. • assess their learning progress and define gaps to be improved. • 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 Product Development and Production: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Engineering Science: Specialisation Mechanical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory Logistics and Mobility: Specialisation Production Management and Processes: Compulsory Logistics and Mobility: Specialisation Engineering Science: Elective Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory 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. Wolfgang Hintze
Language	DE
Cycle	WiSe
Content	• Manufacturing Accuracy • Manufacturing Metrology • Measurement Errors and Uncertainties • Introduction to Forming • Massiv forming and Sheet Metal Forming • Introduction to Machining Technology • 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 Fritz, Alfred Herbert: Fertigungstechnik : mit 62 Tabellen. Berlin [u.a.] : Springer, 2004 Keferstein, Claus P (Dutschke, Wolfgang,;): Fertigungsmesstechnik : praxisorientierte Grundlagen, moderne Messverfahren. Wiesbaden : Teubner, 2008 Mohr, Richard: Statistik für Ingenieure und Naturwissenschaftler : Grundlagen und Anwendung statistischer Verfahren. Renningen : expert-Verl, 2008 Klocke, F., König, W.: Fertigungsverfahren Bd. 1 Drehen, Fäsen, Bohren. 8. Aufl., Springer (2008) Klocke, Fritz (König, Wilfried,;): Umformen. Berlin [u.a.] : Springer, 2006 Paucksch, E.: Zerspantechnik, Vieweg-Verlag, 1996 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. Wolfgang Hintze
Language	DE
Cycle	WiSe
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. Wolfgang Hintze, Prof. Claus Emmelmann
Language	DE
Cycle	SoSe
Content	• Geometrically undefined machining (grinding, lapping, honing) • Introduction into erosion technology • Introduction into blastig processes • Introduction to the manufacturing process forming (Casting, Powder Metallurgy, Composites) • Fundamentals of Laser Technology • Process versions and Fundamentals of Laser Joining Technology
Literature	Klocke, F., König, W.: Fertigungsverfahren Bd. 2 Schleifen, Honen, Läppen, 4. Aufl., Springer (2005) Klocke, F., König, W.: Fertigungsverfahren Bd. 3 Abtragen, Generieren und Lasermaterialbearbeitung. 4. Aufl., Springer (2007) Spur, Günter (Stöferle, Theodor.;): Urformen. München [u.a.] : Hanser, 1981 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. Wolfgang Hintze, Prof. Claus Emmelmann
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1802: Engineering Mechanics I (Stereostatics)

Courses

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

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

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

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

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

Module M0850: Mathematics I

Courses

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

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

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

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

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

Module 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 General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory Data Science: Specialisation II. Application: Elective Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory Logistics and Mobility: Specialisation Engineering Science: Elective Compulsory Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Naval Architecture: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory 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 W.D. Callister: Materials Science and Engineering - An Introduction. 5th ed., John Wiley & Sons, Inc., New York, 2000, ISBN 0-471-32013-7 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	SoSe
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 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	Gregor Vonbun-Feldbauer
Language	DE
Cycle	WiSe
Content	• Motivation: „Atoms in Mechanical Engineering?“ • Basics: Force and Energy • The electromagnetic Interaction • „Detour“: Mathematics (complex e-funktion etc.) • The atom: Bohr's model of the atom • Chemical bounds • The multi part problem: Solutions and strategies • Descriptions of using statistical thermodynamics • Elastic theory of atoms • Consequences of atomar properties on makroskopic Properties: Discussion of examples (metals, semiconductors, hybrid systems)
Literature	Für den **Elektromagnetismus:** • Bergmann-Schäfer: „Lehrbuch der Experimentalphysik“, Band 2: „Elektromagnetismus“, de Gruyter Für die **Atomphysik:** • Haken, Wolf: „Atom- und Quantenphysik“, Springer Für die **Materialphysik und Elastizität:** • Hornbogen, Warlimont: „Metallkunde“, Springer

Module M0577: Non-technical Courses for Bachelors

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

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

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

Module M1006: Team Project MB

Courses

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

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

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 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 2nd 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 Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: 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 2. Fundamental terms 3. Thermal Equilibrium and temperature 3.1 Thermal equation of state 4. First law 4.1 Heat and work 4.2 First law for closed systems 4.3 First law for open systems 4.4 Examples 5. Equations of state and changes of state 5.1 Changes of state 5.2 Cycle processes 6. Second law 6.1 Carnot process 6.2 Entropy 6.3 Examples 6.4 Exergy 7. Thermodynamic properties of pure fluids 7.1 Fundamental equations of Thermodynamics 7.2 Thermodynamic potentials 7.3 Calorific state variables for arbritary fluids 7.4 state equations (van der Waals u.a.)
Literature	• Schmitz, G.: Technische Thermodynamik, TuTech Verlag, Hamburg, 2009 • Baehr, H.D.; Kabelac, S.: Thermodynamik, 15. Auflage, Springer Verlag, Berlin 2012 • 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 M1803: Engineering Mechanics II (Elastostatics)

Courses

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

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

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

Course L1691: Engineering Mechanics II (Elastostatics)	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron, Dr. Konrad Schneider
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 M0851: Mathematics II

Courses

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

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

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

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

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

Module 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 • 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: • explain basic working principles and functions of machine elements, • 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: • accomplish dimensioning calculations of covered machine elements, • transfer knowledge learned in the module to new requirements and tasks (problem solving skills), • recognize the content of technical drawings and schematic sketches, • 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. • 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 Digital Mechanical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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. Dr. Nikola Bursac, Prof. Sören Ehlers
Language	DE
Cycle	SoSe

Content	**Lecture**
	• Introduction to design
	• Introduction to the following machine elements
	  ◦ Screws
	  ◦ Shaft-hub joints
	  ◦ Rolling contact bearings
	  ◦ Welding / adhesive / solder joints
	  ◦ Springs
	  ◦ Axes & shafts
	• Presentation of technical objects (technical drawing)
	Exercise
	• Calculation methods for dimensioning the following machine elements:
	  ◦ Screws
	  ◦ Shaft-hub joints
	  ◦ Rolling contact bearings
	  ◦ Welding / adhesive / solder joints
	  ◦ Springs
	  ◦ Axis & shafts

Literature	• Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage. • Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage. • Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage. • Einführung in die DIN-Normen; Klein, M., Teubner-Verlag. • Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage. • Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage. • Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage. • Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage. • 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. Dr. Nikola Bursac, Prof. Sören Ehlers
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 • 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 complex working principles and functions of machine elements and of basic elements of fluidics, • explain requirements, selection criteria, application scenarios and practical examples of complex machine elements, • indicate the background of dimensioning calculations.
Skills	After passing the module, students are able to: • accomplish dimensioning calculations of covered machine elements, • transfer knowledge learned in the module to new requirements and tasks (problem solving skills), • recognize the content of technical drawings and schematic sketches, • 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. • 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 Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory Engineering Science: Specialisation Mechanical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Compulsory Mechanical Engineering: Core Qualification: Compulsory 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. Dr. Nikola Bursac
Language	DE
Cycle	SoSe

Content	**Advanced Mechanical Engineering Design I & II**
	
	Lecture
	
	• Fundamentals of the following machine elements:
	  ◦ Linear rolling bearings
	  ◦ Axes & shafts
	  ◦ Seals
	  ◦ Clutches & brakes
	  ◦ Belt & chain drives
	  ◦ Gear drives
	  ◦ Epicyclic gears
	  ◦ Crank drives
	  ◦ Sliding bearings
	• Elements of fluidics
	
	Exercise
	
	• Calculation methods of the following machine elements:
	  ◦ Linear rolling bearings
	  ◦ Axes & shafts
	  ◦ Clutches & brakes
	  ◦ Belt & chain drives
	  ◦ Gear drives
	  ◦ Epicyclic gears
	  ◦ Crank gears
	  ◦ Sliding bearings
	• Calculations of hydrostatic systems (fluidics)

Literature	• Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage. • Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage. • Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage. • Einführung in die DIN-Normen; Klein, M., Teubner-Verlag. • Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage. • Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage. • Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage. • Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage. 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. Dr. 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. Dr. Nikola Bursac
Language	DE
Cycle	WiSe

Content	**Advanced Mechanical Engineering Design I & II**
	
	Lecture
	
	• Fundamentals of the following machine elements:
	  ◦ Linear rolling bearings
	  ◦ Axes & shafts
	  ◦ Seals
	  ◦ Clutches & brakes
	  ◦ Belt & chain drives
	  ◦ Gear drives
	  ◦ Epicyclic gears
	  ◦ Crank drives
	  ◦ Sliding bearings
	• Elements of fluidics
	
	Exercise
	
	• Calculation methods of the following machine elements:
	  ◦ Linear rolling bearings
	  ◦ Axes & shafts
	  ◦ Clutches & brakes
	  ◦ Belt & chain drives
	  ◦ Gear drives
	  ◦ Epicyclic gears
	  ◦ Crank gears
	  ◦ Sliding bearings
	• Calculations of hydrostatic systems (fluidics)

Literature	• Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage. • Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage. • Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage. • Einführung in die DIN-Normen; Klein, M., Teubner-Verlag. • Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage. • Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage. • Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage. • Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage. 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. Dr. Nikola Bursac
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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 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** 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 Digital Mechanical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Mechanical Engineering: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation 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 AC: Characteristics, RMS, complexe representation, phasor diagrams, power Three phase AC: Characterisitics, star-delta- connection, power, transformer 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 Ralf Kories, Heinz Schmitt - Walter: "Taschenbuch der Elektrotechnik"; Verlag Harri Deutsch; Signatur der Bibliothek der TUHH: ETB 122 "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: DC networks: Current, voltage, power, Kirchhoff's laws, equivalent sources, network analysis AC: Characteristics, RMS, complexe representation, phasor diagrams, power Three phase AC: Characterisitics, star-delta- connection, power, transformer 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 Ralf Kories, Heinz Schmitt - Walter: "Taschenbuch der Elektrotechnik"; Verlag Harri Deutsch; Signatur der Bibliothek der TUHH: ETB 122 "Grundlagen der Elektrotechnik" - andere Autoren

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 1
Yes	None	Written elaboration	Konstruktionsprojekt 2
Yes	None	Written elaboration	3D-CAD-Praktikum
Yes	None	Written elaboration	Teamprojekt Konstruktionsmethodik

Examination
Written exam

Examination duration and scale
180

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
Digital Mechanical Engineering: Core Qualification: Compulsory
Engineering Science: Specialisation Mechatronics: Compulsory
Engineering Science: Specialisation Mechanical Engineering: Compulsory
Engineering Science: Specialisation Biomedical Engineering: 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
	• Practical course to apply a 3D CAD system
	  ◦ Introduction to the system
	  ◦ Sketching and creation of components
	  ◦ Creation of assemblies
	  ◦ Deriving technical drawings

Literature	• CAx für Ingenieure eine praxisbezogene Einführung; Vajna, S., Weber, C., Bley, H., Zeman, K.; Springer-Verlag, aktuelle Auflage. • Handbuch Konstruktion; Rieg, F., Steinhilper, R.; Hanser; aktuelle Auflage. • Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage. • Technisches Zeichnen: Grundlagen, Normen, Beispiele, Darstellende Geometrie, Hoischen, H; Hesser, W; Cornelsen, aktuelle Auflage. • Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage. • Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage. • Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage. • Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage. • Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage. • 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
	• Consolidation of the following aspects of technical drawings:
	  ◦ Presentation of technical objects and standardized parts
	  (bearings, seals, shaft-hub joints, detachable connections, springs, axes and shafts)
	  ◦ Sectional views
	  ◦ Dimensioning
	  ◦ Tolerances and surface specifications
	  ◦ Creating a tally sheet

Literature	1. Hoischen, H.; Hesser, W.: Technisches Zeichnen. Grundlagen, Normen, Beispiele, darstellende Geometrie, 33. Auflage. Berlin 2011. 2. Labisch, S.; Weber, C.: Technisches Zeichnen. Selbstständig lernen und effektiv üben, 4. Auflage. Wiesbaden 2008. 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 • Approximately calculation of shafts • Dimension of bearings, screw connections and weld • Generation of engineering drawings (assembly drawings, manufacturing drawing)
Literature	**Dubbel, Taschenbuch für Maschinenbau**, Beitz, W., Küttner, K.-H, Springer-Verlag. Maschinenelemente, Band I - III, Niemann, G., Springer-Verlag. **Maschinen- und Konstruktionselemente**, Steinhilper, W., Röper, R., Springer-Verlag. Einführung in die DIN-Normen, Klein, M., Teubner-Verlag. 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
	• Team Project Design Methodology
	  ◦ Creating requirement lists
	  ◦ Problem formulation
	  ◦ Creating functional structures
	  ◦ Finding solutions
	  ◦ Evaluation of the found concepts
	  ◦ 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. • Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage. • Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage. • Einführung in die DIN-Normen; Klein, M., Teubner-Verlag. • Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage. • Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage. • Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage. • Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage. • Sowie weitere Bücher zu speziellen Themen

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 • describe the axiomatic procedure used in mechanical contexts; • explain important steps in model design; • present technical knowledge in kinematics, kinetics and vibrations.
Skills	The students can • explain the important elements of mathematical / mechanical analysis and model formation, and apply it to the context of their own problems; • apply basic kinematic, kinetic and vibraton methods to engineering problems; • 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** / **Bonus** / **Form** / **Description**: No / 20 % / Midterm / 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 Data Science: Core Qualification: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory Integrated Building Technology: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Specialisation Naval Engineering: Compulsory Mechatronics: Specialisation Dynamic Systems and AI: Compulsory Mechatronics: Core Qualification: Compulsory Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory Mechatronics: Specialisation Medical Engineering: Compulsory Naval Architecture: Core Qualification: Compulsory 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 1.1 Motion of a particle 1.2 Planar motion of a rigid body 1.3 Spatial motion of a rigid body 1.4 Spatial relative Kinematics 2 Kinetics 2.1 Linear momentum and change of linear momentum 2.2 Angular momentum and change of angular momentum 2.3 Kinetics of rigid bodies 2.4 Energy and balance of energy 3 Vibrations 3.1 Classification of Vibrations 3.2 Free undamped vibration 3.3 Free damped vibration 3.4 Forced vibration 4. Impact problems 5 Kinetics of gyroscopes 5.1 Free gyroscopic motion 5.2 Forced gyroscopic motion
Literature	K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009). D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 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 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 Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Elective Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Mechatronics: Specialisation Robot- and Machine-Systems: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory 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 7. Gas - vapor - mixtures 10. Open sytems with constant flow rates 11. Combustion processes 12. Special fields of Thermodynamics
Literature	• Schmitz, G.: Technische Thermodynamik, TuTech Verlag, Hamburg, 2009 • Baehr, H.D.; Kabelac, S.: Thermodynamik, 15. Auflage, Springer Verlag, Berlin 2012 • 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. • Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples. • They know proof strategies and can reproduce them.
Skills	• Students can model problems in the area of analysis and differential equations with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods. • Students are able to discover and verify further logical connections between the concepts studied in the course. • For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.
Personal Competence	
Social Competence	• Students are able to work together in teams. They are capable to use mathematics as a common language. • In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.
Autonomy	• Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them. • Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.
Workload in Hours	Independent Study Time 128, Study Time in Lecture 112
Credit points	8
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min (Analysis III) + 60 min (Differential Equations 1)
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Civil- and Environmental Engineering: Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory Logistics and Mobility: Specialisation Information Technology: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Naval Architecture: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Compulsory

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

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

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

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

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

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

Module 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 Minuten
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Elective Compulsory Engineering Science: Specialisation Mechatronics: Elective Compulsory Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory Engineering Science: Specialisation Mechanical Engineering: Compulsory Engineering Science: Specialisation Advanced Materials: Elective Compulsory Logistics and Mobility: Specialisation Production Management and Processes: Compulsory Mechanical Engineering: Core Qualification: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation 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 (B) Product planning (C) Process planning (D) Procurement (E) Manufacturing (F) Production planning and control (PPC) (G) Distribution (H) Cooperation
Literature	Wiendahl, H.-P.: Betriebsorganisation für Ingenieure 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 • Continuous Quality Improvement • Quality Management in Product Development • Quality Management in Production Processes • Design of Experiments
Literature	• Pfeifer, Tilo: Quality Management. Strategies, Methods, Techniques; Hanser-Verlag, München 2002 • Pfeifer, Tilo: Qualitätsmanagement. Strategien, Methoden, Techniken; Hanser-Verlag, München, 3. Aufl. 2001 • Mitra, Amitava: Fundamentals of Quality Control and Improvement; Wiley; Macmillan, 2008 • Kleppmann, W.: Taschenbuch Versuchsplanung. Produkte und Prozesse optimieren; Hanser-Verlag, München, 6. Aufl. 2009

Module M0610: Electrical Machines and Actuators

Courses

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

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

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

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

Module 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 ... • assess their own strengths and weaknesses. • 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 General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory Engineering Science: Specialisation Advanced Materials: Compulsory 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). 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 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 General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory Mechanical Engineering: Core Qualification: Compulsory Naval Architecture: Core Qualification: Compulsory 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
	• dimensional analysis and similitude
	• fluid forces and fluid statics
	• transport and conservation of mass, momentum & energy
	• fluid kinematics
	• technically relevant flow models for incompressible fluids
	  ◦ control volume & stream tube analysis
	  ◦ vortical flow models
	  ◦ potential flows
	  ◦ boundary layer flows
	  ◦ different types of conservation equations and their realm (Navier-Stokes/Euler/Bernoulli equations)
	  ◦ analytical solutions for Navier-Stokes systems
	• Analysis of internal flows (channels, pipes, open channels) and external flows, fundamentals of wing aerodynamics
	• turbulent flows
	• fundamentals of gas dynamics (1D compressible flows)

Literature	• the course primarily refers to / das Modul stütz sich bevorzugt auf : Munson, B.R.; Rothmayer, A.P.; Okiishi, T.H.; Huebsch, W.W.: **Fundamentals of Fluid Mechanics**, John Wiley & Sons. • Spurk, J.; Aksel, N.: Strömungslehre, Springer. • Schade, H.; Kunz, E., Kameier, F.; Paschereit, C.O.: Strömungslehere, De Gruyter. • Herwig, H.: Strömungsmechanik, Springer. • 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 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 • describe the axiomatic procedure used in mechanical contexts; • explain important steps in model design; • present technical knowledge.
Skills	The students can • explain the important elements of mathematical / mechanical analysis and model formation, and apply it to the context of their own problems; • apply basic methods from numerical mechanics to engineering problems; • 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
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 General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory Mechatronics: Specialisation Medical Engineering: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory 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). 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 • Linear versus nonlinear vibration • Numerical methods for time integration • Vibrations with multiple degrees of freedom: free, damped, forced, modal transformation • Concepts from analytical mechanics • Spatial multibody systems • Linearization of multibody systems • Introduction to Matlab
Literature	K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009). D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1-4. 11. Auflage, Springer (2011). 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
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: • Basics of linear continuum mechanics • Planar structures: plate, membrane, slab • Linientragwerke: beam, cable, truss • Weak form and Galerkin's method • Finite element method: theory and application • Principles of mechanics: principle of virtual work, virtual displacements, virtual forces
Literature	Gross, Hauger, Wriggers, "Technische Mechanik 4", Springer

Module M0596: Advanced Mechanical Design Project

Courses

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

Module Responsible	Dr. Jens Schmidt
Admission Requirements	None
Recommended Previous Knowledge	• Mechanical Engineering: Design • 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: • express the procedure for systematically handling of • complex design tasks , • describe working principles, their use and combination possibilities, • explain guidelines for designing for function and manufacturing, • explain advanced use-oriented knowledge of machine elements.
Skills	After passing the module, students are able to: • analyze complex tasks and develop principle solutions using sketches, • convert principle solutions into a detailed design, • use methods to design and solve engineering design tasks systematically and solution-oriented, • create a technical documentation including all necessary technical drawings to understand the functions of the system, • document calculations of selected machine elements clearly and in detail.
Personal Competence	
Social Competence	After passing the module, students are able to: • present and discuss solutions and technical drawings within groups, • reflect the own results in the work groups of the course
Autonomy	After passing the module, students are able to: • independently solve complex design projects, while motivating themselves, acquiring necessary knowledge and selecting appropriate methods, • 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 General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory 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	Das Konstruktionsprojekt gliedert sich in den Entwurf eines Getriebes sowie die Lösungsfindung.
	• Getriebekonstruktion in Einzelarbeit
	  ◦ Erarbeitung von Lösungsprinzipien
	  ◦ Berechnung von Maschinenelementen
	  ◦ Entwurf eines Getriebes im Hauptschnitt plus allen Außenansichten
	  ◦ Erstellung einer ausführlichen Dokumentation
	• Lösungsfindung
	  ◦ Methodische Erarbeitung von prinzipiellen Lösungskonzepten
	  ◦ Erstellen einer Dokumentation

Literature	• Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage. • Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage. • Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage. • Einführung in die DIN-Normen; Klein, M., Teubner-Verlag. • Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage. • Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage. • Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage. • Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage. • Sowie weitere Bücher zu speziellen Themen

Module M0956: 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

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). They can outline the most important measuring methods for different kinds of quantities to be maesured (Electrical Quantities, Temperature, mechanical quantities, Flow, Time, Frequency). 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. 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** / **Bonus** / **Form** / **Description** Yes / None / Subject theoretical and practical work
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 General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Elective Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Engineering Science: Specialisation Mechatronics: Compulsory Engineering Science: Specialisation Mechanical Engineering: Compulsory Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory Engineering Science: Specialisation Advanced Materials: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechatronics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Elective Compulsory Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Specialisation Naval Engineering: Compulsory Mechatronics: Specialisation Electrical Systems: Compulsory Mechatronics: Specialisation Dynamic Systems and AI: Compulsory Mechatronics: Core Qualification: Compulsory Mechatronics: Specialisation Robot- and Machine-Systems: Compulsory Mechatronics: Specialisation Medical Engineering: Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation 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:** 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 radius of a sphere is determined using three different measurement methods (manual measurement, manual measurement with a sensor, automatic data acquisition and data processing). **The content of experiment 3:** 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. **The content of experiment 4:** 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: • 1)Weck, Manfred; Brecher, Christian. Maschinenarten und Anwendungsbereiche. Springer (Werkzeugmaschinen, 1, Ed. 6). 2005 • 2)Weck, Manfred; Brecher, Christian. Automatisierung von Maschinen und Anlagen. Springer (Werkzeugmaschinen, 4, Ed. 6). 2006 • 3)Siciliano, Bruno; Khatib, Oussama. Springer handbook of robotics. Springer. 2008 • 4)Schüppstuhl, Thorsten. VL Grundlagen der Handhabungs- und Montagetechnik. 2017 Versuch 3: • 1)Hompel, Michael, Hubert Büchter, and Ulrich Franzke. Identifikationssysteme und Automatisierung. Springer-Verlag, 2007. • ArUco Library Documentation, https://docs.google.com/document/d/1QU9KoBtjSM2kF6lTOjQ76xqL7H0TEtXriJX5kwi9Kgc/edit Stand 10/21 • Demant, Christian, Bernd Streicher-Abel, and Axel Springhoff. Industrielle Bildverarbeitung: wie optische Qualitätskontrolle wirklich funktioniert. Springer-Verlag, 2011. Versuch 4: • 1)Will, Thorsten T. C++ Das umfassende Handbuch, Rheinwerk Computing, 2020 • 2)Hildebrand, Walter. Grundkurs Regelungstechnik : Grundlagen für Bachelorstudiengänge aller technischen Fachrichtungen und Wirtschaftsingenieure, Springer Vieweg, 2013. • 3)Erlenkötter, Helmut. C++: Objektorientiertes Programmieren von Anfang an, rororo, 2016 Bibliography: Experiment 1 • 1)Weck, Manfred; Brecher, Christian. Maschinenarten und Anwendungsbereiche. Springer (Werkzeugmaschinen, 1, Ed. 6). 2005 • 2)Weck, Manfred; Brecher, Christian. Automatisierung von Maschinen und Anlagen. Springer (Werkzeugmaschinen, 4, Ed. 6). 2006 • 3)Siciliano, Bruno; Khatib, Oussama. Springer handbook of robotics. Springer. 2008 • 4)Schüppstuhl, Thorsten. VL Grundlagen der Handhabungs- und Montagetechnik. 2017 Experiment 3: • 1)Hompel, Michael, Hubert Büchter, and Ulrich Franzke. Identifikationssysteme und Automatisierung. Springer-Verlag, 2007. • ArUco Library Documentation, https://docs.google.com/document/d/1QU9KoBtjSM2kF6lTOjQ76xqL7H0TEtXriJX5kwi9Kgc/edit Stand 10/21 • Demant, Christian, Bernd Streicher-Abel, and Axel Springhoff. Industrielle Bildverarbeitung: wie optische Qualitätskontrolle wirklich funktioniert. Springer-Verlag, 2011. Experiment 4: • 1)Will, Thorsten T. C++ Das umfassende Handbuch, Rheinwerk Computing, 2020 • 2)Hildebrand, Walter. Grundkurs Regelungstechnik : Grundlagen für Bachelorstudiengänge aller technischen Fachrichtungen und Wirtschaftsingenieure, Springer Vieweg, 2013. • 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 1.1 Quantities and Units 1.2 Uncertainty 1.3 Calibration 1.4 Static and Dynamic Properties of Sensors and Systems 2 Measurement of Electrical Quantities 2.1 Current and Voltage 2.2 Impedance 2.3 Amplification 2.4 Oscilloscope 2.5 Analog-to-Digital Conversion 2.6 Data Transmission 3 Measurement of Nonelectric Quantities 3.1 Temperature 3.2 Length, Displacement, Angle 3.3 Strain, Force, Pressure 3.4 Flow 3.5 Time, Frequency
Literature	Lerch, R.: „Elektrische Messtechnik; Analoge, digitale und computergestützte Verfahren“, Springer, 2006, ISBN: 978-3-540-34055-3. 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 M0833: Introduction to Control Systems

Courses

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

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

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

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

Module M0829: Foundations of Management

Courses

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

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

	Naval Architecture: Core Qualification: Compulsory Technomathematics: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory

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

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

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

Module Responsible	Prof. Udo Schumacher
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. 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 General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory Data Science: Specialisation II. Application: Elective Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Mechatronics: Specialisation Medical Engineering: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory 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	PD Thorsten Frenzel
Language	DE
Cycle	SoSe
Content	**General Anatomy** **1st week: The Eucaryote Cell** **2nd week: The Tissues** **3rd week: Cell Cycle, Basics in Development** **4th week: Musculoskeletal System** **5th week: Cardiovascular System** **6th week: Respiratory System** **7th week: Genito-urinary System** **8th week: Immune system** **9th week: Digestive System I** **10th week: Digestive System II** **11th week: Endocrine System** **12th week: Nervous System** **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. Ulrich Carl
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	**Therapy** The students can distinguish different types of currently used equipment with respect to its use in radiation therapy. The students can explain treatment plans used in radiation therapy in interdisciplinary contexts (e.g. surgery, internal medicine). **The students can describe the patients' passage from their initial admittance through to follow-up care.** **Diagnostics** The students can illustrate the technical base concepts of projection radiography, including angiography and mammography, as well as sectional imaging techniques (CT, MRT, US). The students can explain the diagnostic as well as therapeutic use of imaging techniques, as well as the technical basis for those techniques. The students can choose the right treatment method depending on the patient's clinical history and needs. The student can explain the influence of technical errors on the imaging techniques. The student can draw the right conclusions based on the images' diagnostic findings or the error protocol.
Skills	**Therapy** The students can distinguish curative and palliative situations and motivate why they came to that conclusion. The students can develop adequate therapy concepts and relate it to the radiation biological aspects. The students can use the therapeutic principle (effects vs adverse effects) 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). 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). **Diagnostics** The students can suggest solutions for repairs of imaging instrumentation after having done error analyses. 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. 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. The students can introduce younger students to the clinical daily routine. 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 General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory Data Science: Specialisation II. Application: Elective Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Mechatronics: Specialisation Medical Engineering: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory

	Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory 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	Prof. Ulrich Carl, Prof. Thomas Vestring
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 – 7. Auflage – Deutscher Ärzteverlag – erschienen 1999 • "Klinische Strahlenbiologie" von Th. Herrmann, M. Baumann und W. Dörr – 4. Auflage - Verlag Urban & Fischer – erschienen 02.03.2006 ISBN: 978-3-437-23960-1 • "Strahlentherapie und Onkologie für MTA-R" von R. Sauer – 5. Auflage 2003 - Verlag Urban & Schwarzenberg – erschienen 08.12.2009 ISBN: 978-3-437-47501-6 • "Taschenatlas der Physiologie" von S. Silbernagel und A. Despopoulus- 8. Auflage – Georg Thieme Verlag - erschienen 19.09.2012 ISBN: 978-3-13-567708-8 • "Der Körper des Menschen " von A. Faller u. M. Schünke - 16. Auflage 2004 – Georg Thieme Verlag – erschienen 18.07.2012 ISBN: 978-3-13-329716-5 • „Praxismanual Strahlentherapie“ von Stöver / Feyer – 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 • describe basic biomolecules; • explain how genetic information is coded in the DNA; • explain the connection between DNA and proteins;
Skills	The students can • recognize the importance of molecular parameters for the course of a disease; • describe selected molecular-diagnostic procedures; • 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. 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. 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 General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Mechatronics: Specialisation Medical Engineering: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory 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 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. Michael Morlock
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. 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	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 General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Orientation Studies: Core Qualification: Elective Compulsory 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. Michael Morlock
Language	DE
Cycle	WiSe
Content	Topics to be covered include: 1. Introduction (history, definitions, background importance) 2. Bone (anatomy, properties, biology, adaptations in femur, tibia, humerus, radius) 3. Spine (anatomy, biomechanics, function, vertebral bodies, intervertebral disc, ligaments) 3.1 The spine in its entirety 3.2 Cervical spine 3.3 Thoracic spine 3.4 Lumbar spine 3.5 Injuries and diseases 4. Pelvis (anatomy, biomechanics, fracture treatment) 5 Fracture Healing 5.1 Basics and biology of fracture repair 5.2 Clinical principals and terminology of fracture treatment 5.3 Biomechanics of fracture treatment 5.3.1 Screws 5.3.2 Plates 5.3.3 Nails 5.3.4 External fixation devices 5.3.5 Spine implants 6.0 New Implants
Literature	Cochran V.B.: Orthopädische Biomechanik Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics White A.A., Panjabi M.M.: Clinical biomechanics of the spine Nigg, B.: Biomechanics of the musculo-skeletal system Schiebler T.H., Schmidt W.: Anatomie 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	Dr. Roger Zimmermann
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 • describe the basics of the energy metabolism; • 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. 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 General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Elective Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Mechatronics: Specialisation Medical Engineering: Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory 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 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	Prof. Michael Morlock
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. 1. Tribology 2. Optical Methods 3. Motion Analysis 4. Pressure Distribution 5. Strain Gauges 6. Pre-clinical testing 7. Specimen Preparation and Storage The students can describe the different ways how bones heal, and the requirements for their existence. The students can name different treatments for the spine and hollow bones under given fracture morphologies. 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 General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Elective Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Mechatronics: Specialisation Medical Engineering: Elective Compulsory 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	Prof. Michael Morlock, Dr. Gerd Huber
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. 1. Tribology 2. Optical Methods 3. Motion Analysis 4. Pressure Distribution 5. Strain Gauges 6. Pre-clinical testing 7. Specimen Preparation and Storage
Literature	Hoffmann K., Eine Einführung in die Technik des Messens mit Dehnmessstreifen White A.A., Panjabi M.M.: Clinical biomechanics of the spine Nigg, B.: Biomechanics of the musculo-skeletal system 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 M0684: Heat Transfer

Courses

Title	Typ	Hrs/wk	CP
Heat Transfer (L0458)	Lecture	3	4
Heat Transfer (L0459)	Recitation Section (large)	2	2

Module Responsible	Dr. Andreas Moschallski
Admission Requirements	None
Recommended Previous Knowledge	Technical Thermodynamics I, II and Fluid Dynamics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can - explain the technical terms, - classify the various physical processes of heat transfer in terms of conduction-based and radiation-based mechanisms, - simplify and critically analyze complex heat transfer processes using models, - methodically develop solutions to tasks.
Skills	The students are able to - describe the physics of the different Heat Transfer mechanism, - simplifywith models, calculate and evaluate complex Heat Transfer processes, - critically question and answer statements on heat transfer, - solve excersises self-consistent and in small groups.
Personal Competence	
Social Competence	In lectures and exercises, the students can use many examples and experiments to discuss in small groups in a goal-oriented manner, develop a solution and present it. Within the exercises, the students can independently develop further questions and work out targeted solutions.
Autonomy	The students can check their level of knowledge by means of repetition questions at the beginning of the lectures and describe and discuss answers in exchange with the other students. In the exercises, the students work in small groups on the methods taught in the lectures in complex tasks and critically analyze the results in the auditorium.
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 General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory Integrated Building Technology: Core Qualification: Compulsory Mechanical Engineering: Specialisation Energy Systems: Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Elective Compulsory

Course L0458: Heat Transfer	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Dr. Andreas Moschallski
Language	DE
Cycle	WiSe
Content	Dimensional analysis, Heat Conduction (steady and unsteady) , Convective Heat Transfer (natural convection, forced convection), Two-phase Heat Transfer (evaporation, condensation), Thermal Radiation, Heat Transfer on a thermodynamic view, thermotechnical devices, measures of temperature and heat flux
Literature	- Herwig, H.; Moschallski, A.: Wärmeübertragung, 4. Auflage, Springer Vieweg Verlag, Wiesbaden, 2019 - Herwig, H.: Wärmeübertragung von A-Z, Springer- Verlag, Berlin, Heidelberg, 2000 - Baehr, H.D.; Stephan, K.: Wärme- und Stoffübertragung, 2. Auflage, Springer Verlag, Berlin, Heidelberg, 1996

Course L0459: Heat Transfer	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Andreas Moschallski
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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. 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 Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory 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
	  ◦ Historischer Rückblick
	  ◦ Einteilung der Verbrennungsmotoren
	  ◦ Arbeitsverfahren
	  ◦ Vergleichsprozesse
	  ◦ Arbeit, Mitteldrücke, Leistungen
	  ◦ Arbeitsprozess des wirklichen Motors
	  ◦ Wirkungsgrade
	  ◦ Gemischbildung und Verbrennung
	  ◦ Motorkennfeld und Betriebskennlinien
	  ◦ Abgasentgiftung
	  ◦ Gaswechsel
	  ◦ Aufladung
	  ◦ Kühl- und Schmiersystem
	  ◦ Kräfte im Triebwerk
	• Kolbenverdichter
	  ◦ Thermodynamik des Kolbenverdichters
	  ◦ Einteilung und Verwendung
	• Kolbenpumpen
	  ◦ Prinzip der Kolbenpumpen
	  ◦ Einteilung und Verwendung

Literature	• A. Urlaub: Verbrennungsmotoren • 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. Wolfgang Thiemann
Language	DE
Cycle	SoSe
Content	• The beginnings of engine development • Design of of motors • Real process calculation • Charging methods • Kinematics of the crank mechanism • Forces in the engine
Literature	• Vorlesungsskript • Übungsaufgaben mit Lösungsweg • 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. Wolfgang Thiemann
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 General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: Elective Compulsory Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Naval Architecture: Core Qualification: Compulsory 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	Prof. Thomas Rung
Language	DE
Cycle	WiSe
Content	Fundamentals of computational modelling of thermofluid dynamic problems. Development of numerical algorithms. 1. Partial differential equations 2. Foundations of finite numerical approximations 3. Computation of potential flows 4. Introduction of finite-differences 5. Approximation of convective, diffusive and transient transport processes 6. Formulation of boundary conditions and initial conditions 7. Assembly and solution of algebraic equation systems 8. Facets of weighted -residual approaches 9. Finite volume methods 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	Prof. Thomas Rung
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0639: Gas and Steam Power Plants

Courses

Title	Typ	Hrs/wk	CP
Gas and Steam Power Plants (L0206)	Lecture	3	5
Gas and Steam Power Plants (L0210)	Recitation Section (large)	1	1

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	• "Technical Thermodynamics I and II" • "Heat Transfer" • "Fluid Mechanics"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can evaluate the development of the electricity demand and the energy conversion routes in the thermal power plant, describe the various types of power plant and the layout of the steam generator block. They are also able to determine the operation characteristics of the power plant. Additionally they can describe the exhaust gas cleaning apparatus and the combination possibilities of conventional fossil-fuelled power plants with solar thermal and geothermal power plants or plants equipped with Carbon Capture and Storage. The students have basic knowledge about the principles, operation and design of turbomachinery
Skills	The students will be able, using theories and methods of the energy technology from fossil fuels and based on well-founded knowledge on the function and construction of gas and steam power plants, to identify basic associations in the production of heat and electricity, so as to develop conceptual solutions. Through analysis of the problem and exposure to the inherent interplay between heat and power generation the students are endowed with the capability and methodology to develop realistic optimal concepts for the generation of electricity and the production of heat. From the technical basics the students become the ability to follow better the deliberations on the electricity mix composition within the energy-political triangle (economy, secure supply and environmental protection). Within the framework of the exercise the students learn the use of the specialised software suite EBSILON Professional ™. With this tool small practical tasks are solved with the PC, to highlight aspects of the design and development of power plant cycles. The students are able to do simplified calculations on turbomachinery either as part of a plant, as single component or at stage level.
Personal Competence	
Social Competence	An excursion within the framework of the lecture is planned for students that are interested. The students get in this manner direct contact with a modern power plant in this region. The students will obtain first-hand experience with a power plant in operation and gain insights into the conflicts between technical and political issues.
Autonomy	The students assisted by the tutors will be able to develop alone simple simulation models and run with these scenario analyses. In this manner the theoretical and practical knowledge from the lecture is consolidated and the potential effects from different process combinations and boundary conditions highlighted. The students are able independently to analyse the operational performance of steam power plants and calculate selected quantities and characteristic curves.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6

Course achievement

Compulsory	Bonus	Form	Description
No	5 %	Excercises	10 Übungsaufgaben im Laufe der Vorlesungen à 5 Minuten; bis zu 5 % Bonus je nach Anteil richtiger Abgaben
No	5 %	Group discussion	gemeinsame Erarbeitung von Inhalten
No	5 %	Written elaboration	Zusammenfassung von Literatur
No	5 %	Presentation	15-minütiges, unbenotetes Testat über EBSILON Professional; nur bestanden/nicht bestanden (keine anteiligen Punkte)

Examination	Written exam
Examination duration and scale	Written examination of 120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory

Course L0206: Gas and Steam Power Plants	
Typ	Lecture
Hrs/wk	3
CP	5
Workload in Hours	Independent Study Time 108, Study Time in Lecture 42
Lecturer	Dr. Kristin Abel-Günther
Language	DE
Cycle	WiSe
Content	In the 1st part of the lecture an overview on thermal power plants is offered, including: • Electricity demand and Forecasting • Thermodynamic fundamentals • Energy Conversion in thermal power plants • Types of power plant • Layout of the power plant block • Individual elements of the power plant • Cooling systems • Flue gas cleaning • Operation characteristics of the power plant • Construction materials for power plants • Location of power plants • Solar thermal plants/geothermal plants/Carbon Capture and Storage plants. These are complemented in the 2nd part of the module by the more specialised issues: • Energy balance of a turbomachine • Theory of turbine and compressor stage • Equal and positive pressure blading • Flow losses • Characteristic numbers • Axial and radial design • Design features • Hydraulic turbomachines • Pump and water turbine designs • Design examples of reciprocating engines and turbomachinery • Steam power plants • Gas turbine systems.
Literature	• Kalide: Kraft- und Arbeitsmaschinen • Thomas, H.J.: Thermische Kraftanlagen. Springer-Verlag, 1985 • Strauß, K.: Kraftwerkstechnik. Springer-Verlag, 2006 • Kugeler und Phlippen: Energietechnik. Springer-Verlag, 1990 • Bohn, T. (Hrsg.): Handbuchreihe Energie, Band 7: Gasturbinenkraftwerke, Kombikraftwerke, Heizkraftwerke und Industriekraftwerke, Technischer Verlag Resch / Verlag TÜV Rheinland

Course L0210: Gas and Steam Power Plants	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Kristin Abel-Günther
Language	DE
Cycle	WiSe
Content	In the 1st part of the lecture a general introduction into fluid-flow machines and steam power plants is offered, including: • Energy balance of a fluid-flow machine • Theory of turbine and compressor stage • Equal and positive pressure blading • Flow losses • Characteristic numbers • Axial and radial design • Design features • Hydraulic fluid-flow machines • Pump and water turbine designs • Design examples of reciprocating engines and turbomachinery • Steam power plants • Gas turbine systems • Diesel engine systems • Waste heat utilisation followed by the more specialised issues: • Electricity Demand and Forecasting • Thermodynamic fundamentals • Energy Conversion in Thermal Power Plants • Types of Power Plant • Layout of the power plant block • Individual elements of the power plant • Cooling systems • Flue gas cleaning • Operation characteristics of the power plant • Construction materials • Location of power plants The environmental impact of acidification, fine particulate or CO_2 emissions and the resulting climatic effects are a special focus of the lecture and the lecture hall exercise. The challenges in plant operation from interconnecting conventional power plants and renewable energy sources are discussed and the technical options for providing security of supply and network stability are presented, also under consideration of cost effectiveness. In this critical review, focus is especially placed on the compatibility of the different solutions with the environment and climate. With this, the awareness for the responsibility of an engineer's own actions are emphasized and the potential extent of the different solutions presented clearly. Within the framework of the exercise the students learn the use of the specialised software suite EBSILON Professional ™. With this tool small tasks are solved on the PC, to highlight aspects of the design and development of power plant cycles. The students present their results orally and can afterwards ask questions and get feedback. The course work has a positive effect on the students final grade.
Literature	• Skripte • Kalide: Kraft- und Arbeitsmaschinen • Thomas, H.J.: Thermische Kraftanlagen. Springer-Verlag, 1985 • Strauß, K.: Kraftwerkstechnik. Springer-Verlag, 2006 • Kugeler und Phlippen: Energietechnik. Springer-Verlag, 1990 • T . Bohn (Hrsg.): Handbuchreihe Energie, Band 7: Gasturbinenkraftwerke, Kombikraftwerke, Heizkraftwerke und Industriekraftwerke, Technischer Verlag Resch / Verlag TÜV Rheinland

Module M0662: Numerical Mathematics I

Courses

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

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

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

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

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 M1573: 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	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory Engineering Science: Core Qualification: Compulsory Engineering Science: Specialisation Advanced Materials: Compulsory Engineering Science: Specialisation Mechanical Engineering: Compulsory Engineering Science: Specialisation Mechatronics: Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory Mechanical Engineering: Specialisation Mechatronics: Compulsory Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory 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 • Overview of modelling approaches • Finite Approximation Methods - Finite Differences / Elements / Volumes • Introduction to the Discrete Element Method • Numerical methods for time dependent problems • Gradient-based optimization
Literature	Michael Schäfer, Computational Engineering - Introduction to Numerical Methods, Springer.

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: Fundamentals of Mechanical Engineering Design Mechanical Engineering: Design 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: • explaining the functional principle of 3D-CAD-Systems, PDM- and FEM-Systems • describing the interaction of the different CAE-Systems in the product development process
Skills	After completing the module, students are able to: • evaluate different CAD- and PDM-Systems with regards to the desired requirements such as classification schemes and product structuring • 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: • To develop a project plan and allocate work appropriate work packages in the framework of group discussions • Present project results as a team for instance in a presentation
Autonomy	Students are capable of: • 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 General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Elective Compulsory Mechanical Engineering: Specialisation Product Development and Production: Compulsory Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory 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) • Team formation, allocation of tasks and generation of a project plan • Collective creation of one product out of CAD models supported by FEM calculations and PDM system • Manufacturing of selected parts using 3D printer • Presentation of results **Description** 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	-

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 • 3D CAD -Systems and CAD interfaces • Administration of part lists / PDM systems • PDM in different industries • Selection of CAD-/PDM Systems • Simulation • Construction methods • Design for X
Literature	• Ehrlenspiel, K.: Integrierte Produktentwicklung, München, Carl Hanser Verlag • Lee, K.: Principles of CAD / CAM / CAE Systems, Addison Wesles • Schichtel, M.: Produktdatenmodellierung in der Praxis, München, Carl Hanser Verlag • Anderl, R.: CAD Schnittstellen, München, Carl Hanser Verlag • 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 • Product development process for lightweight structures • Dimensioning of lightweight structures
Literature	• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, 2005. • Klein, B., „Leichtbau-Konstruktion", Vieweg & Sohn, Braunschweig, 1989. • Krause, D., „Leichtbau”, In: Handbuch Konstruktion, Hrsg.: Rieg, F., Steinhilper, R., München, Carl Hanser Verlag, 2012. • Schulte, K., Fiedler, B., „Structure and Properties of Composite Materials”, Hamburg, TUHH - TuTech Innovation GmbH, 2005. • 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 Data Science: Specialisation II. Application: Elective Compulsory Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation 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 • Hydraulic and electrical power systems, landing gear systems, flight-control and high-lift systems, air conditioning systems
Literature	• Shevell, R. S.: Fundamentals of Flight • TÜV Rheinland: Luftfahrtzeugtechnik in Theorie und Praxis • 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 2. Legal basis of air transportation 3. Safety and security aspects 4. Aircraft basics 5. The role of the aircraft amnufacturer 6. The role of the aircraft operator 7. Airport operation 8. The principles of air traffic management 9. Environmental aspects of air transportation
Literature	1. V. Gollnick, D. Schmitt: "Air Transport System", Springer-Verlag, ISBN 978-3-7091-1879-5 2. H. Mensen: "Handbuch der Luftfahrt", Springer-Verlag, 2003 3. J.P. Clark: “Buying the Big Jets”, ISBN 9781317170341 , Taylor & Francis, 2017 4. Mike Hirst: The Air Transport System, AIAA, 2008 5. D.P. Raymer: "Aircraft Design - A Conceptual Approach", AIAA Education Series, 2006, ISBN 1-56347-281-3 6. N. Ashford: "Airport Operations", McGraw-Hill, 1997, ISBN 0-07-003077-4 7. P. Maurer: "Luftverkehrsmanagement", Oldenbourg-Verlag, ISBN 3-486-27422-8 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

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. Kaline Pagnan Furlan
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 General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory Engineering Science: Specialisation Advanced Materials: Compulsory Engineering Science: Specialisation Advanced Materials: Compulsory Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory Mechanical Engineering: Specialisation Product Development and Production: Compulsory Mechanical Engineering: Specialisation Materials in Engineering Sciences: Compulsory 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. Kaline Pagnan Furlan
Language	DE/EN
Cycle	WiSe
Content	- Introduction to the Materials Science Laboratory practical course and learning modules; - Collection of data: source of errors and sample distribution; - Error calculation; - Report writing and presentation of results; - 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') 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. Kaline Pagnan Furlan, Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Patrick Huber
Language	DE/EN
Cycle	WiSe
Content	5 laboratory experiments: - Metals: Tensile test - Plastics: Scanning electron microscopy on fracture surfaces of fiber reinforced plastics - Plastics: Bending test - bending properties of carbon fiber reinforced plastics - Ceramics: Ceramic synthesis - From raw material up to sintered product - Ceramics: Mechanical testing - hardness and fracture toughness of ceramic materials
Literature	1) Vorlesungsunterlagen Grundlagen der Werkstoffwissenschaft I & II 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
Materials for Energy Storage and Conversion (DE) (L1086)	Lecture	2	3
Enhanced Fundamentals: Ceramics and Polymers (L1233)	Lecture	2	2
Enhanced Fundamentals: Ceramics and Polymers (L1234)	Recitation Section (large)	1	1

Module Responsible	Prof. Gerold Schneider
Admission Requirements	None
Recommended Previous Knowledge	Module "Fundamentals of Materials Science" Module "Materials Science Laboratory" 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	Data Science: Core Qualification: Elective Compulsory Mechanical Engineering: Specialisation Materials in Engineering Sciences: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

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
Cycle	SoSe
Content	Advanced understanding of metals: • Physical materials properties o Materials behaviour - elastic, thermal, electrical o Superelasticity and shape memory effect o Fundamentals of electrical conductivity in metals and semiconductors o Superconductivity • Chemical (or "dry") corrosion o Driving forces and mechanisms o Passivation o Growth laws • Introduction to electrochemistry o Electrolytes o Ions o Solvatation o Dissolution and deposition of metals o Galvanic cells and cell voltage o Galvanic series o Nernst equation o Polarizable electrodes o Electrochemical double layer o Capacitive and pseudocapacitive processes o Capacitive currents and Faraday currents • Electrochemical (or "wet") corrosion and corrosion protection o Basic observations o Galvanic corrosion

	o Protection against galvanic corrosion o Stainless steel o sacrificial anodes o Passivation and Pourbaix diagrams o Corrosion through gas reduction o Crevice corrosion o Stress corrosion cracking o Alloy corrosion and nanoporous metals • Electrochemical energy storage o How a battery works o Lead accumulators o Alkaline batteries o Nickel-metal hydride accumulators o Flux batteries o Lithium-ion accumulators o Electrolytic and super capacitors o Fuel cells • Materials for hydrogen storage o Storage strategies o Requirements for storage materials o State of the art • Magnetism and magnetic materials o Phenomenology: magnetic field and magnetization o Para-, ferro-, antiferromagnets; Curie transition o Magnetism at the atomic scale; exchange coupling o Magnetization isotherms, domains o Measurement methods o Magnetocrystalline anisotropy and domain walls o Hard magnetic materials and their applications o Soft magnetic materials and their applications
Literature	- Vorlesungsskript - W.D. Callister, „Materialwissenschaften und Werkstofftechnik “, Wiley-VCH 2012 - Carl H. Hamann, Wolf Vielstich, "Elektrochemie", Wiley-VCH; 4. Auflage 2005 - Kurzweil, Dietlmeier, "Elektrochemische Speicher" Springer Vieweg (2015) (eBook: https://link.springer.com/book/10.1007/978-3-658-10900-4) - B. D. Cullity, C.D. Graham, "Introduction to magnetic materials", John Wiley & Sons, 2011 - D. Jiles, "Introduction to magnetism and magnetic materials", CRC press, 2015

Course L1233: Enhanced Fundamentals: Ceramics and Polymers	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Gerold Schneider, Prof. Robert Meißner
Language	DE/EN
Cycle	SoSe
Content	1. Einführung Natürliche „Keramiken“ - Steine „Künstliche“ Keramik - vom Porzellan bis zur Hochleistungskeramik Anwendungen von Hochleistungskeramik 2. Pulverherstellung Einteilung der Pulversyntheseverfahren Der Bayer-Prozess zur Al2O3-Herstellung Der Acheson-Prozess zur SiC-Herstellung Chemical Vapour Deposition Pulveraufbereitung Mahltechnik Sprühtrockner 3. Formgebung Arten der Formgebung Pressen (0 - 15 % Feuchte) Gießen (> 25 % Feuchte) Plastische Formgebung (15 - 25 % Feuchte) 4. Sintern Triebkraft des Sinterns Effekt von gekrümmten Oberflächen und Diffusionswegen Sinterstadien des isothermen Festphasensinterns Herring scaling laws Heißisostatisches Pressen 5. Mechanische Eigenschaften von Keramiken Elastisches und plastisches Materialverhalten Bruchzähigkeit - Linear-elastische Bruchmechanik Festigkeit - Festigkeitsstreuung 6. Elektrische Eigenschaften von Keramiken Ferroelektische Keramiken Piezo-, ferroelektrische Materialeigenschaften Anwendungen Keramische Ionenleiter Ionische Leitfähigkeit Dotiertes Zirkonoxid in der Brennstoffzelle und Lambdasonde
Literature	D R H Jones, Michael F. Ashby, Engineering Materials 1, An Introduction to Properties, Applications and Design, Elesevier D.W. Richerson, Modern Ceramic Engineering, Marcel Decker, New York, 1992 W.D. Kingery, Introduction to Ceramics, John Wiley & Sons, New York, 1975 D.J. Green, An introduction to the mechanical properties of ceramics”, Cambridge University Press, 1998 D. Munz, T. Fett, Ceramics, Springer, 2001 Polymerwerkstoffe Struktur und mechanische Eigenschaften G.W.Ehrenstein; Hanser Verlag; ISBN 3-446-12478-0; ca. 20 € Kunststoffphysik W.Retting, H.M.Laun; Hanser Verlag; ISBN 3446162356; ca. 25 € Werkstoffkunde Kunststoffe G.Menges; Hanser Verlag; ISBN 3-446-15612-7; ca. 25 € Kunststoff-Kompendium A.Frank, K. Biederbick; Vogel Buchverlag; ISBN 3-8023-0135-8; ca.30 €

Course L1234: Enhanced Fundamentals: Ceramics and Polymers	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Gerold Schneider, Prof. Robert Meißner
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

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

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. 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 • 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 • to relate the deformation behavior to the underlying microstructural mechanisms • to assess how processing procedures affect the chain microstructure - process - properties • 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 • actively enrich and shape the course by contributing to the discussion. • 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, • assess their own strengths and weaknesses • concretely assess their respective learning status and define further work steps on this basis • 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.

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 Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory Engineering Science: Specialisation Advanced Materials: Compulsory Engineering Science: Specialisation Advanced Materials: Compulsory 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 2. Fundamentals of plasticity in metals and alloys 3. Modellierung von Materialverhalten 4. Plasticity in cyclic loading 5. Rate dependency, recristallization 6. Rolling, forming, and solid state joining processes 7. Residual stress design
Literature	• Hull and Bacon: Introduction to Dislocations (1984) • G. Gottstein: Physik. Grundlagen der Materialk. (2001) • P. Haupt: Cont. Mechanics and Theory of Materials (2002) • 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 2. Overview of fabrication processes 3. Shape considerations: macrostructural aspects 4. Material properties: microstructural aspects 5. Materials engineering: microstructure, shape and processing relation 6. Materials engineering: function and costs relation
Literature	1. K.P. Furlan, Lecture slides “Materials Selection and Processing (lv2861)”, StudIP E-learning system, TUHH 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’) 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 M0854: Mathematics IV

Courses

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

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

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

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

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

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

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

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

Module M0777: Semiconductor Circuit Design

Courses

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

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

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

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

Module M1573: 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	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory Engineering Science: Core Qualification: Compulsory Engineering Science: Specialisation Advanced Materials: Compulsory Engineering Science: Specialisation Mechanical Engineering: Compulsory Engineering Science: Specialisation Mechatronics: Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory Mechanical Engineering: Specialisation Mechatronics: Compulsory Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory 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 • Overview of modelling approaches • Finite Approximation Methods - Finite Differences / Elements / Volumes • Introduction to the Discrete Element Method • Numerical methods for time dependent problems • Gradient-based optimization
Literature	Michael Schäfer, Computational Engineering - Introduction to Numerical Methods, Springer.

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 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. Kaline Pagnan Furlan
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 General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory Engineering Science: Specialisation Advanced Materials: Compulsory Engineering Science: Specialisation Advanced Materials: Compulsory Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory Mechanical Engineering: Specialisation Product Development and Production: Compulsory Mechanical Engineering: Specialisation Materials in Engineering Sciences: Compulsory 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. Kaline Pagnan Furlan
Language	DE/EN
Cycle	WiSe
Content	- Introduction to the Materials Science Laboratory practical course and learning modules; - Collection of data: source of errors and sample distribution; - Error calculation; - Report writing and presentation of results; - 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') 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. Kaline Pagnan Furlan, Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Patrick Huber
Language	DE/EN
Cycle	WiSe
Content	5 laboratory experiments: - Metals: Tensile test - Plastics: Scanning electron microscopy on fracture surfaces of fiber reinforced plastics - Plastics: Bending test - bending properties of carbon fiber reinforced plastics - Ceramics: Ceramic synthesis - From raw material up to sintered product - Ceramics: Mechanical testing - hardness and fracture toughness of ceramic materials
Literature	1) Vorlesungsunterlagen Grundlagen der Werkstoffwissenschaft I & II 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 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 internship recommended 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 ... • explain the basics of chip formation and mechanisms and models of machining. • explain methods and parameters for design and analysis of metal forming, machining processes and tools. • explain technical concepts of machine tool building and give an overview on trends in the machine tool industry. • explain types, constructions and functions of CNC-machines and give an overview on multi-machine systems. • explain equipment components.
Skills	Students are able to... • select tool geometry, cutting materials, process parameters and appropriate measuring technique in accordance with the requirements. • estimate occurring forces and temperatures during chip formation. • select appropriate machine tools for machining and create NC programs for turning and milling. • assess the quality of a machine tools and to detect weak points.
Personal Competence	
Social Competence	Students are able to ... • develop solutions in a production environment with qualified personnel at technical level and represent decisions.
Autonomy	Students are able to ... • interpret independently cutting processes. • create independently NC programs. • select independently machine tools by reference to appropriate requirements. • assess own strengths and weaknesses in general. • assess their learning progress and define gaps to be improved. • 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 Mechanical Engineering: Specialisation Product Development and Production: Compulsory Mechatronics: Specialisation Robot- and Machine-Systems: Elective Compulsory 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 CNC controls NC programming and NC programming systems Types, construction and function of CNC machines Multi-machinesystems Equipmentcomponents for machine tools Assessment of machine tools
Literature	*Conrad, K.J* *Taschenbuch der Werkzeugmaschinen* *9783446406414* *Fachbuchverlag 2006* *Perović, Božina* *Spanende Werkzeugmaschinen - Ausführungsformen und Vergleichstabellen* *ISBN: 3540899529* *Berlin [u.a.]: Springer, 2009* *Weck, Manfred* *Werkzeugmaschinen 1 - Maschinenarten und Anwendungsbereiche* *ISBN: 9783540225041* *Berlin [u.a.]: Springer, 2005* *Weck, Manfred; Brecher, Christian* *Werkzeugmaschinen 4 - Automatisierung von Maschinen und Anlagen* *ISBN: 3540225072* *Berlin [u.a.]: Springer, 2006* *Weck, Manfred; Brecher, Christian* *Werkzeugmaschinen 5 - Messtechnische Untersuchung und Beurteilung, dynamische Stabilität* *ISBN: 3540225056* *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 • Chip Formation, Forces, Temperature and Tribology process • Wear mechanisms and wear patterns • Machinability by Cutting and Forming, Specific Problems of Light Weight Structures • Cutting Material and Coatings • Methods and Parameters for Analysis and Configuration of Forming and Cutting Processes and Tools
Literature	Lange, K.; Umformtechnik Grundlagen, 2. Auflage, Springer (2002) Tönshoff, H.; Spanen Grundlagen, 2. Auflage, Springer Verlag (2004) König, W., Klocke, F.; Fertigungsverfahren Bd. 4 *Massivumformung*, 4. Auflage, VDI-Verlag (1996) König, W., Klocke, F.; Fertigungsverfahren Bd. 5 *Blechbearbeitung*, 3. Auflage, VDI-Verlag (1995) Klocke, F., König, W.; Fertigungsverfahren *Schleifen, Honen, Läppen*, 4. Auflage, Springer Verlag (2005) 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 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: Fundamentals of Mechanical Engineering Design Mechanical Engineering: Design 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: • explaining the functional principle of 3D-CAD-Systems, PDM- and FEM-Systems • describing the interaction of the different CAE-Systems in the product development process
Skills	After completing the module, students are able to: • evaluate different CAD- and PDM-Systems with regards to the desired requirements such as classification schemes and product structuring • 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: • To develop a project plan and allocate work appropriate work packages in the framework of group discussions • Present project results as a team for instance in a presentation
Autonomy	Students are capable of: • 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 General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Elective Compulsory Mechanical Engineering: Specialisation Product Development and Production: Compulsory Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory 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) • Team formation, allocation of tasks and generation of a project plan • Collective creation of one product out of CAD models supported by FEM calculations and PDM system • Manufacturing of selected parts using 3D printer • Presentation of results **Description** 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	-

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 • 3D CAD -Systems and CAD interfaces • Administration of part lists / PDM systems • PDM in different industries • Selection of CAD-/PDM Systems • Simulation • Construction methods • Design for X
Literature	• Ehrlenspiel, K.: Integrierte Produktentwicklung, München, Carl Hanser Verlag • Lee, K.: Principles of CAD / CAM / CAE Systems, Addison Wesles • Schichtel, M.: Produktdatenmodellierung in der Praxis, München, Carl Hanser Verlag • Anderl, R.: CAD Schnittstellen, München, Carl Hanser Verlag • 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 • Product development process for lightweight structures • Dimensioning of lightweight structures
Literature	• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, 2005. • Klein, B., „Leichtbau-Konstruktion", Vieweg & Sohn, Braunschweig, 1989. • Krause, D., „Leichtbau”, In: Handbuch Konstruktion, Hrsg.: Rieg, F., Steinhilper, R., München, Carl Hanser Verlag, 2012. • Schulte, K., Fiedler, B., „Structure and Properties of Composite Materials”, Hamburg, TUHH - TuTech Innovation GmbH, 2005. • 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 • basic MATLAB/Python knowledge
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to • name numerical methods for interpolation, integration, least squares problems, eigenvalue problems, nonlinear root finding problems and to explain their core ideas, • repeat convergence statements for the numerical methods, • explain aspects for the practical execution of numerical methods with respect to computational and storage complexitx.
Skills	Students are able to • implement, apply and compare numerical methods using MATLAB/Python, • justify the convergence behaviour of numerical methods with respect to the problem and solution algorithm, • select and execute a suitable solution approach for a given problem.
Personal Competence	
Social Competence	Students are able to • work together in heterogeneously composed teams (i.e., teams from different study programs and background knowledge), explain theoretical foundations and support each other with practical aspects regarding the implementation of algorithms.
Autonomy	Students are capable • to assess whether the supporting theoretical and practical excercises are better solved individually or in a team, • to assess their individual progess and, if necessary, to ask questions and seek help.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 minutes
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory General Engineering Science (German program, 7 semester): Specialisation Data Science: Compulsory Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Data Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Engineering Science: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory Computer Science in Engineering: Core Qualification: Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

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

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

Module M0684: Heat Transfer

Courses

Title	Typ	Hrs/wk	CP
Heat Transfer (L0458)	Lecture	3	4
Heat Transfer (L0459)	Recitation Section (large)	2	2

Module Responsible	Dr. Andreas Moschallski
Admission Requirements	None
Recommended Previous Knowledge	Technical Thermodynamics I, II and Fluid Dynamics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can - explain the technical terms, - classify the various physical processes of heat transfer in terms of conduction-based and radiation-based mechanisms, - simplify and critically analyze complex heat transfer processes using models, - methodically develop solutions to tasks.
Skills	The students are able to - describe the physics of the different Heat Transfer mechanism, - simplifywith models, calculate and evaluate complex Heat Transfer processes, - critically question and answer statements on heat transfer, - solve excersises self-consistent and in small groups.
Personal Competence	
Social Competence	In lectures and exercises, the students can use many examples and experiments to discuss in small groups in a goal-oriented manner, develop a solution and present it. Within the exercises, the students can independently develop further questions and work out targeted solutions.
Autonomy	The students can check their level of knowledge by means of repetition questions at the beginning of the lectures and describe and discuss answers in exchange with the other students. In the exercises, the students work in small groups on the methods taught in the lectures in complex tasks and critically analyze the results in the auditorium.
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 General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory Integrated Building Technology: Core Qualification: Compulsory Mechanical Engineering: Specialisation Energy Systems: Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Elective Compulsory

Course L0458: Heat Transfer	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Dr. Andreas Moschallski
Language	DE
Cycle	WiSe
Content	Dimensional analysis, Heat Conduction (steady and unsteady) , Convective Heat Transfer (natural convection, forced convection), Two-phase Heat Transfer (evaporation, condensation), Thermal Radiation, Heat Transfer on a thermodynamic view, thermotechnical devices, measures of temperature and heat flux
Literature	- Herwig, H.; Moschallski, A.: Wärmeübertragung, 4. Auflage, Springer Vieweg Verlag, Wiesbaden, 2019 - Herwig, H.: Wärmeübertragung von A-Z, Springer- Verlag, Berlin, Heidelberg, 2000 - Baehr, H.D.; Stephan, K.: Wärme- und Stoffübertragung, 2. Auflage, Springer Verlag, Berlin, Heidelberg, 1996

Course L0459: Heat Transfer	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Andreas Moschallski
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1573: 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	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Elective Compulsory Engineering Science: Core Qualification: Compulsory Engineering Science: Specialisation Advanced Materials: Compulsory Engineering Science: Specialisation Mechanical Engineering: Compulsory Engineering Science: Specialisation Mechatronics: Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory Mechanical Engineering: Specialisation Mechatronics: Compulsory Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory Mechanical Engineering: Specialisation Aircraft Systems Engineering: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory 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 • Overview of modelling approaches • Finite Approximation Methods - Finite Differences / Elements / Volumes • Introduction to the Discrete Element Method • Numerical methods for time dependent problems • 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. • Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples. • They know proof strategies and can reproduce them.
Skills	• Students can model problems in Mathematics IV with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods. • Students are able to discover and verify further logical connections between the concepts studied in the course. • For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.
Personal Competence	
Social Competence	• Students are able to work together in teams. They are capable to use mathematics as a common language. • In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.
Autonomy	• Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them. • Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.
Workload in Hours	Independent Study Time 68, Study Time in Lecture 112
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	60 min (Complex Functions) + 60 min (Differential Equations 2)
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory Electrical Engineering: Core Qualification: Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Mechanical Engineering: Specialisation Mechatronics: Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Elective Compulsory Mechatronics: Core Qualification: Compulsory Naval Architecture: Core Qualification: Compulsory Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory

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

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

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

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

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

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

Module M1595: Machine Learning I

Courses

Title	Typ	Hrs/wk	CP
Machine Learning I (L2432)	Lecture	2	3
Machine Learning I (L2433)	Recitation Section (small)	3	3

Module Responsible	Prof. Nihat Ay
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra, Analysis, Basic Programming Course
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students know • general principles of machine learning learning: supervised/unsupervised learning, generative/descriptive learning, parametric/non-parametric learning • different learning methods: neural networks, support vector machines, clustering, dimensionality reduction, kernel methods • fundamentals of statistical learning theory • advanced techniques such as transfer learning, reinforcement learning, generative adversarial networks and adaptive control
Skills	The students can • apply machine learning methods to concrete problems • select and evaluate suitable methods for specific problems • evaluate the quality of a trained data-driven model • work with known software frameworks for machine learning • adapt the architecture and cost function of neural networks to specific problems • show the limits of machine learning methods
Personal Competence	
Social Competence	Students can work on complex problems both independently and in teams. They can exchange ideas with each other and use their individual strengths to solve the problem.
Autonomy	Students are able to independently investigate a complex problem and assess which competencies are required to solve it.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	Compulsory: No; Bonus: 20 %; Form: Excercises; 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 General Engineering Science (German program, 7 semester): Specialisation Data Science: Compulsory Computer Science: Specialisation I. Computer and Software Engineering: Elective Compulsory Data Science: Core Qualification: Compulsory Engineering Science: Specialisation Advanced Materials: Elective Compulsory Engineering Science: Specialisation Mechatronics: Elective Compulsory Engineering Science: Specialisation Data Science: Compulsory Engineering Science: Specialisation Mechanical Engineering: Elective Compulsory Computer Science in Engineering: Specialisation I. Computer Science: Elective Compulsory Logistics and Mobility: Specialisation Information Technology: Elective Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Elective Compulsory Mechatronics: Specialisation Dynamic Systems and AI: Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Elective Compulsory

Course L2432: Machine Learning I	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Nihat Ay
Language	DE/EN
Cycle	SoSe
Content	• History of neuroscience and machine learning (in particular, the age of deep learning) • McCulloch-Pitts neurons and binary Artificial Neural Networks • Boolean and threshold functions • Universality of McCulloch-Pitts neural networks • Learning and the perceptron convergence theorem • Support vector machines • Harmonic analysis of Boolean functions • Continuous Artificial Neural Networks • Kolmogorov's superposition theorem • Universal approximation with continuous neural networks • Approximation error and the gradient decent method: the general idea • The stochastic gradient decent method (Robbins-Monro and Kiefer-Wolfowitz cases) • Multilayer networks and the backpropagation algorithm • Statistical Learning Theory
Literature	• Martin Anthony and Peter L. Bartlett. Neural Network Learning: Theoretical Foundations. Cambridge University Press, 1999. • Martin Anthony. Discrete Mathematics of Neural Networks: Selected Topics. SIAM Monographs on Discrete Mathematics & Applications, 1987. • Mehryar Mohri, Afshin Rostamizadeh and Ameet Talwalkar. Foundations of Machine Learning, Second Edition. MIT Press, 2018. • Christopher M. Bishop. Pattern Recognition and Machine Learning. Information Science and Statistics. Springer-Verlag, 2008. • Bernhard Schölkopf, Alexander Smola. Learning with Kernels: Support Vector Machines, Regularization, Optimization, and Beyond. Adaptive Computation and Machine Learning series. MIT Press, Cambridge, MA, 2002. • Luc Devroye, László Györfi, Gábor Lugosi. A Probabilistic Theory of Pattern Recognition. Springer, 1996. • Vladimir Vapnik. The Nature of Statistical Learning Theory. Springer-Verlag: New York, Berlin, Heidelberg, 1995.

Course L2433: Machine Learning I	
Typ	Recitation Section (small)
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Nihat Ay
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking 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): At least 126 ECTS credit points have to be achieved in study programme. The examinations board decides on exceptions.
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• The students can select, outline and, if need be, critically discuss the most important scientific fundamentals of their course of study (facts, theories, and methods). • On the basis of their fundamental knowledge of their subject the students are capable in relation to a specific issue of opening up and establishing links with extended specialized expertise. • The students are able to outline the state of research on a selected issue in their subject area.
Skills	• The students can make targeted use of the basic knowledge of their subject that they have acquired in their studies to solve subject-related problems. • With the aid of the methods they have learnt during their studies the students can analyze problems, make decisions on technical issues, and develop solutions. • The students can take up a critical position on the findings of their own research work from a specialized perspective.
Personal Competence	
Social Competence	• Both in writing and orally the students can outline a scientific issue for an expert audience accurately, understandably and in a structured way. • The students can deal with issues in an expert discussion and answer them in a manner that is appropriate to the addressees. In doing so they can uphold their own assessments and viewpoints convincingly.
Autonomy	• The students are capable of structuring an extensive work process in terms of time and of dealing with an issue within a specified time frame. • The students are able to identify, open up, and connect knowledge and material necessary for working on a scientific problem. • The students can apply the essential techniques of scientific work to research of their own.
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0
Credit points	12
Course achievement	None
Examination	Thesis
Examination duration and scale	According to General Regulations
Assignment for the Following Curricula	General Engineering Science (German program): Thesis: Compulsory General Engineering Science (German program, 7 semester): Thesis: Compulsory Civil- and Environmental Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Data Science: Thesis: Compulsory Digital Mechanical Engineering: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Engineering Science: Thesis: Compulsory General Engineering Science (English program): Thesis: Compulsory General Engineering Science (English program, 7 semester): Thesis: Compulsory Green Technologies: Energy, Water, Climate: Thesis: Compulsory Computer Science in Engineering: Thesis: Compulsory Integrated Building Technology: Thesis: Compulsory Logistics and Mobility: Thesis: Compulsory Mechanical Engineering: Thesis: Compulsory Mechatronics: Thesis: Compulsory Naval Architecture: Thesis: Compulsory Technomathematics: Thesis: Compulsory Teilstudiengang Lehramt Metalltechnik: Thesis: Compulsory

	Process Engineering: Thesis: Compulsory Engineering and Management - Major in Logistics and Mobility: Thesis: Compulsory