TUHH
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Module Manual

Bachelor of Science (B.Sc.)

Technomathematics

Cohort: Winter Term 2021

Updated: 21st June 2023

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Program description

Content

Core Qualification

Module M0718: Linear Algebra for Technomathematicians

Courses

Title	Typ	Hrs/wk	CP
Linear Algebra 1 for Technomathematicians (L0587)	Lecture	4	5
Linear Algebra 1 for Technomathematicians (L0588)	Recitation Section (small)	2	4
Linear Algebra 2 for Technomathematicians (L0589)	Lecture	4	5
Linear Algebra 2 for Technomathematicians (L0590)	Recitation Section (small)	2	4

Module Responsible	Prof. Sabine Le Borne
Admission Requirements	None
Recommended Previous Knowledge	High school mathematics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to • define the basic terms of Linear Algebra, illustrate them with examples and detect interrelations, • list techniques for proofs, • sketch main steps in proofs of central theorems. Students can furthermore explain the basic steps that arise in modelling and relate them to application scenarios.
Skills	Students are capable to • apply the tools of Linear Algebra, • implement (MATLAB) and test algorithms (e.g. solution of linear systems of equations, computation of the determinant, computation of eigenvalues and eigenvectors), • develop proofs for propositions in Linear Algebra and to document them in a comprehensible manner.
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, • explain solutions/proofs of the excercises at the blackboard in a way suitable for the audience (in the excercise sessions).
Autonomy	Students are capable • to assess whether the supporting theoretical and practical excercises are better solved individually or in a team, • to work on complex problems over an extended period of time, • to assess their individual progess and, if necessary, to ask questions and seek help.
Workload in Hours	Independent Study Time 372, Study Time in Lecture 168
Credit points	18
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Orientation Studies: Core Qualification: Elective Compulsory Technomathematics: Core Qualification: Compulsory

Course L0587: Linear Algebra 1 for Technomathematicians	
Typ	Lecture
Hrs/wk	4
CP	5
Workload in Hours	Independent Study Time 94, Study Time in Lecture 56
Lecturer	Prof. Sabine Le Borne, Prof. Anusch Taraz
Language	DE
Cycle	WiSe
Content	1. Proof techniques, sets, relations, functions 2. Groups and Fields 3. Vector spaces 4. Applications of vector spaces 5. Linear mappings 6. Polynomials 7. Determinants
Literature	• G. Fischer, Lineare Algebra: Eine Einführung für Studienanfänger • A. Beutelspacher: Lineare Algebra: Eine Einführung in die Wissenschaft der Vektoren, Abbildungen und Matrizen • J. Liesen, V. Mehrmann: Lineare Algebra: Ein Lehrbuch über die Theorie mit Blick auf die Praxis • G. Strang: Introduction to Linear Algebra

Course L0588: Linear Algebra 1 for Technomathematicians	
Typ	Recitation Section (small)
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Sabine Le Borne, Prof. Anusch Taraz
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0589: Linear Algebra 2 for Technomathematicians	
Typ	Lecture
Hrs/wk	4
CP	5
Workload in Hours	Independent Study Time 94, Study Time in Lecture 56
Lecturer	Prof. Sabine Le Borne, Prof. Anusch Taraz
Language	DE
Cycle	SoSe
Content	1. Eigenvalues 2. Bilinear forms 3. Singular value decomposition 4. Tensor products 5. Application: Linear ordinary differential equations
Literature	siehe Lineare Algebra 1 für Technomathematiker

Course L0590: Linear Algebra 2 for Technomathematicians	
Typ	Recitation Section (small)
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Sabine Le Borne, Prof. Anusch Taraz
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1436: Procedural Programming for Computer Engineers

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Procedural Programming for Computer Engineers (L2163)	Lecture	1	2
Procedular Programming for Computer Engineers (L2164)	Recitation Section (large)	1	1
Procedural Programming for Computer Engineers (L2165)	Practical Course	2	3

Module Responsible	NN
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 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	Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Compulsory Computational Science and Engineering: Core Qualification: Compulsory Technomathematics: Core Qualification: Compulsory

Course L2163: Procedural Programming for Computer Engineers

Typ	Lecture
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Siegfried Rump
Language	DE/EN
Cycle	WiSe
Content	
Literature	

Course L2164: Procedular Programming for Computer Engineers

Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dozenten des SD E
Language	DE/EN
Cycle	WiSe
Content	
Literature	

Course L2165: Procedural Programming for Computer Engineers

Typ	Practical Course
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des SD E
Language	DE/EN
Cycle	WiSe
Content	
Literature	

Module M0889: Mechanics I (Statics)

Courses

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

Module Responsible	Prof. Robert Seifried
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 Data Science: Specialisation Mechanics: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Elective Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective 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 Technomathematics: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory

Course L1001: Mechanics I (Statics)	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried
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 L1002: Mechanics I (Statics)	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Robert Seifried
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 L1003: Mechanics I (Statics)	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Robert Seifried
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 M0690: Analysis for Technomathematicians

Courses

Title	Typ	Hrs/wk	CP
Analysis I for Technomathematicians (L0483)	Lecture	4	5
Analysis I for Technomathematicians (L0484)	Recitation Section (small)	2	4
Analysis II for Technomathematicians (L0485)	Lecture	4	5
Analysis II for Technomathematicians (L0486)	Recitation Section (small)	2	4

Module Responsible	Prof. Marko Lindner
Admission Requirements	None
Recommended Previous Knowledge	High school mathematics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to • name, define and explain the basic properties of the field of real numbers, • define and interrelate the basic topological terms in a metric space, • in particular, describe their interrelation with the concepts of convergence and continuiuty, • define, explain and use the basic terms of differential calculus in several veriables and integral calculus in one variable, In particular, they are able to correctly define, explain and interrelate all these concepts and to sketch the main ideas in proofs of central theorems. Students can furthermore explain the basic steps that arise in modelling and relate them to application scenarios.
Skills	Students are able to • determine topological properties of concrete sets in metric space, • determine and prove convergence and divergence of sequences and series - as well as continuity, uniform continuity and Lipschitz continuity of a given function between two metric spaces, • differentiate a function in one or several variables, • decide whether a given function is Riemann integrable and compute its integral, • compute Taylor polynomial and Taylor series of a given, sufficiently smooth, function in one or more variables, • find local and global extrema of a given function - possibly under constraints
Personal Competence	
Social Competence	Students are able to solve specific problems in groups (e.g. in connection with their regular homework) and to present their results appropriately (e.g. during exercise class).
Autonomy	Students are able to • gain further information from additional literature and put it in context with the contents of the lecture, • put their knowledge in relation to the contents of other lectures, • work on difficult problems over a long period.
Workload in Hours	Independent Study Time 372, Study Time in Lecture 168
Credit points	18
Course achievement	None
Examination	Written exam
Examination duration and scale	120
Assignment for the Following Curricula	Orientation Studies: Core Qualification: Elective Compulsory Technomathematics: Core Qualification: Compulsory

Course L0483: Analysis I for Technomathematicians

Typ	Lecture
Hrs/wk	4
CP	5
Workload in Hours	Independent Study Time 94, Study Time in Lecture 56
Lecturer	Prof. Marko Lindner, Prof. Matthias Schulte, Prof. Sabine Le Borne
Language	DE
Cycle	WiSe
Content	• logic, sets • cardinalities • numbers • metric space and convergence • continuity
Literature	• K. Königsberger: Analysis I und II • O. Forster: Analysis 1 und 2 • H. Heuser: Lehrbuch der Analysis. Teile 1 und 2

Course L0484: Analysis I for Technomathematicians	
Typ	Recitation Section (small)
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Marko Lindner, Prof. Matthias Schulte, Prof. Sabine Le Borne
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0485: Analysis II for Technomathematicians	
Typ	Lecture
Hrs/wk	4
CP	5
Workload in Hours	Independent Study Time 94, Study Time in Lecture 56
Lecturer	Prof. Marko Lindner, Prof. Sabine Le Borne
Language	DE
Cycle	SoSe
Content	• differentiation in 1D • integration in 1D • sequences and series of functions • differentiation in several variables
Literature	• K. Königsberger: Analysis I und II • O. Forster: Analysis 1 und 2 • H. Heuser: Lehrbuch der Analysis. Teile 1 und 2

Course L0486: Analysis II for Technomathematicians	
Typ	Recitation Section (small)
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Marko Lindner, Prof. Sabine Le Borne
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

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 M1519: Introduction to Electrical Engineering (Technomathematics)

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Introduction to Electrical Engineering (Technomathematics) (L2292)	Lecture	3	4
Introduction to Electrical Engineering (Technomathematics) (L2293)	Recitation Section (small)	2	2

Module Responsible	Prof. Christian Kautz
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	
Skills	
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	online exercises, short presentation, presence exercise, short oral exam
Assignment for the Following Curricula	Technomathematics: Core Qualification: Compulsory

Course L2292: Introduction to Electrical Engineering (Technomathematics)

Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christian Kautz
Language	DE
Cycle	SoSe
Content	
Literature	

Course L2293: Introduction to Electrical Engineering (Technomathematics)

Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Kautz
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1432: Programming Paradigms

Courses

Title	Typ	Hrs/wk	CP
Programming Paradigms (L2169)	Lecture	2	2
Programming Paradigms (L2170)	Recitation Section (large)	1	1
Programming Paradigms (L2171)	Practical Course	2	3

Module Responsible	Dr. Thibaut Lunet
Admission Requirements	None
Recommended Previous Knowledge	Lecture on procedural programming or equivalent programming skills
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students have a fundamental understanding of object orientated and generic programming and can apply it in small programming projects. The can design own class hierarchies and differentiate between different ways of inheritance. They have a fundamental understanding of polymorphism and can differentiate between run-time and compile-time polymorphism. The students know the concept of information hiding and can design interfaces with public and private methods. They can use exceptions and apply generic programming in order to make existing data structures generic. The students know the pros and cons of both programming paradigms.
Skills	Students can break down a medium-sized problem into subproblems and create their own classes in an object-oriented programming language based on these subproblems. They can design a public and private interface and implement the implementation generically and extensible by abstraction. They can distinguish different language constructs of a modern programming language and use these suitably in the implementation. They can design and implement unit tests.
Personal Competence	
Social Competence	Students can work in teams and communicate in forums.
Autonomy	In a programming internship, students learn object-oriented programming under supervision. In exercises they develop individual and independent solutions and receive feedback.
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	Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Compulsory Computational Science and Engineering: Core Qualification: Compulsory Technomathematics: Core Qualification: Compulsory

Course L2169: Programming Paradigms

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Thibaut Lunet
Language	DE/EN
Cycle	SoSe
Content	• fundamentals behind object orientated programming • classes and objects • inheritance (single, multiple) • interfaces • information hiding • exception handling • generic programming and the implementation in the compiler • excursus in programming with dynamically typed programming languages
Literature	Skript

Course L2170: Programming Paradigms	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Thibaut Lunet
Language	DE/EN
Cycle	SoSe
Content	• fundamentals behind object orientated programming • classes and objects • inheritance (single, multiple) • interfaces • information hiding • exception handling • generic programming and the implementation in the compiler • excursus in programming with dynamically typed programming languages
Literature	Skript

Course L2171: Programming Paradigms	
Typ	Practical Course
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Thibaut Lunet
Language	DE/EN
Cycle	SoSe
Content	• fundamentals behind object orientated programming • classes and objects • inheritance (single, multiple) • interfaces • information hiding • exception handling • generic programming and the implementation in the compiler • excursus in programming with dynamically typed programming languages
Literature	Skript

Module M1113: Proseminar Technomathematics

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Proseminar Mathematics (L0919)	Seminar	2	2

Module Responsible	Prof. Anusch Taraz
Admission Requirements	None
Recommended Previous Knowledge	• Analysis & Linear Algebra I + II for Technomathematicians **or** • Mathematik I + II (for Engineering Students - German or English lecture series), and • an advanced course by the lecturer who is responsible for the proseminar
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students acquire a deep understanding of the mathematical subject under consideration.
Skills	Students are able to • understand, analyze, classify and work on an advanced mathematical topic, • thoroughly study the recommended literature, • present their results in a mathematically correct and comprehensible way.
Personal Competence	
Social Competence	Students are able to present their results in an appropriate way to the group.
Autonomy	Students are able to prepare a written scientific presentation on their own; in particular to • find and critically check relevant literature, • make and incorporate their own thoughts, • complete the presentation in time.
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Credit points	2
Course achievement	None
Examination	Presentation
Examination duration and scale	60 Minutes
Assignment for the Following Curricula	Technomathematics: Core Qualification: Compulsory

Course L0919: Proseminar Mathematics	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Anusch Taraz, Dozenten des Fachbereiches Mathematik der UHH, Dr. Christian Seifert, Dr. Haibo Ruan, Dr. Julian Großmann, Dr. Mijail Guillemard, Prof. Heinrich Voß, Prof. Marko Lindner, Prof. Sabine Le Borne
Language	DE
Cycle	WiSe/SoSe
Content	Selected topics from the fields • Applied Analysis • Numerical Linear Algebra • Computational mathematics • Discrete mathematics
Literature	wird in der Lehrveranstaltung bekannt gegeben

Module M1075: Numerical Mathematics

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Numerical Mathematics (L1357)	Lecture	4	6
Numerical Mathematics (L1358)	Recitation Section (small)	2	3

Module Responsible	Prof. Jens Struckmeier
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra Analysis
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts in Numerical Mathematics such as moethods for linear systems of equations and their error analysis, interpolation by polynomials and splines, orthogonalization methods, linear regression, linear optimization, numerical integration, nonlinear equations and eigenvalue problems. 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 Numerical Mathematics ith 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Technomathematics: Core Qualification: Compulsory

Course L1357: Numerical Mathematics	
Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe
Content	• Linear systems of equations, error analysis • Interpolation by polynomials and splines • Orthogonalization methods, linear regression • Linear optimization, in particular simplex method • Numerical integration • Nonlinear equations • Eigenvalue problems
Literature	• **Numerische Mathematik,** Jochen Werner, Vieweg, 1992 • **Numerische Mathematik,** Robert Schaback, Holger Wendland, Auflage: 5., vollst. neu bearb. Aufl. 2005 (8. September 2004), **Sprache:** Deutsch, **ISBN-10:** 3540213945, **ISBN-13:** 978-3540213949 • **Numerische Mathematik,** Hans-Rudolf Schwarz, Norbert Köckler, Vieweg+Teubner Verlag, 2011, **ISBN:** 3834815519 **ISBN:** 9783834815514 • **Stoer/Bulirsch: Numerische Mathematik 1,** Roland Freund, Ronald Hoppe, Springer; Auflage: 10., neu bearb. Aufl. 2007 (18. April 2007), **Sprache:** Deutsch, **ISBN-10:** 354045389X, **ISBN-13:** 978-3540453895 • **Numerische Mathematik I,** Peter Deuflhard, Andreas Hohmann**,** Gruyter; Auflage: 3., überarb. A. (18. April 2002), Deutsch, **ISBN-10:** 3110171821, **ISBN-13:** 978-3110171822

Course L1358: Numerical Mathematics	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1085: Mathematical Stochastics

Courses

Title	Typ	Hrs/wk	CP
Mathematical Stochastics (L1392)	Lecture	4	6
Mathematical Stochastics (L1393)	Recitation Section (small)	2	3

Module Responsible	Prof. Holger Drees
Admission Requirements	None
Recommended Previous Knowledge	• Analysis • Linear Algebra
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge*	• Students can describe basic concepts in Mathematical Stochastics such as probability measures and random experiments, random variables and pushforward measures, classification numbers of random variables and distributions, transition probabilities and stochastic independence, law of large numbers and limit theorems, measurable functions and general measure integral. • 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 Stochastics 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Technomathematics: Core Qualification: Compulsory

Course L1392: Mathematical Stochastics	
Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe
Content	• Probability measures and random experiments • Random variables and pushforward measures, classification numbers of random variables and distributions • Multi-level models: Transition probabilities and stochastic independence • Law of large numbers and central limit theorem, Poisson's limit theorem • Measurable functions and general measure integral, application in stochastics • Treatment of selected problems of statistics, stochastic processes, insurance mathematics • Problems of stochastic modelling
Literature	• K. Behnen und G. Neuhaus (2003). Grundkurs Stochastik (4. Aufl.). PD-Verlag • P. Billingsley (1995). Probability and Measure (3. ed.). Wiley. • H. Dehling und B. Haupt (2003). Einführung in die Wahrscheinlichkeitstheorie und Statistik. Springer. • C. Hesse (2003). Angewandte Wahrscheinlichkeitstheorie. Vieweg Verlag. • U. Krengel (2000). Einführung in die Wahrscheinlichkeitstheorie und Statistik. Vieweg.

Course L1393: Mathematical Stochastics	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1074: Higher Analysis

Courses

Title	Typ	Hrs/wk	CP
Higher Analysis (L1355)	Lecture	4	6
Higher Analysis (L1356)	Recitation Section (small)	2	3

Module Responsible	Prof. Vicente Cortés
Admission Requirements	None
Recommended Previous Knowledge	• Analysis • Linear Algebra
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts in Higher Analysis such as submanifolds, tangential bundles, Lebesgue integration theory, fundamentals of funktional analysis, the Hilbert space L^2, Fourier analysis, L^p spaces, classical inequalities and fundamentals of general measure and integration theory. 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 Higher Analysis 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Technomathematics: Core Qualification: Compulsory

Course L1355: Higher Analysis

Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe

Content	• Submanifolds of R^n
	• Tangential bundles
	  ◦ Differential of differentiable mappings
	  ◦ Integral theorems for submanifolds (in general form)
	• Lebesgue integration theory
	• Fundamentals of funktional analysis
	• Hilbert space L^2 and Fourier analysis
	• L^p spaces
	• Classical inequalities
	• Fundamentals of general measure and integration theory

Literature	**a) Vektoranalysis - Differentialformen in Analysis, Geometrie und Physik** • Autoren: Ilka Agricola, Thomas Friedrich • Vieweg + Teubner Verlag, 2. Auflage, 2010 • Sprache: Deutsch • ISBN-10: 3834810169 • ISBN-13**:** 978-3834810168 **b) Analysis 3: Maß- und Integrationstheorie, Integralsätze im IRn und Anwendungen** (Aufbaukurs Mathematik) • Autor: Otto Forster • Vieweg+Teubner Verlag; Auflage: 7., überarb. Aufl. 2012 • Sprache: Deutsch • ISBN-10: 3834823732 • ISBN-13: 978-3834823731 **c) Höhere Analysis,** • Autor: R. Lauterbach (Skript, WS 09/10, verfügbar auf http://www.math.uni-hamburg.de/home/lauterbach/analysis3_WS0910.html#skript) **d) Real and complex analysis** • Autor: Walter Rudin • Verlag: Oldenbourg Wissenschaftsverlag (25. August 1999) • Sprache: Deutsch • ISBN-10: 3486247891 • ISBN-13: 978-3486247893 **oder** **Real and complex analysis** • Autor: Walter Rudin • McGraw-Hill, 1987 , 3. illustrierte Neuauflage • Sprache: Englisch • Digitalisiert: 2. Febr. 2010 • ISBN: 0070542341, 9780070542341 **e) An Introduction to Measure Theory (Graduate Studies in Mathematics)** • Autor: Terence Tao • Verlag: American Mathematical Society (15. September 2011) • Sprache: Englisch • ISBN-10: 0821869191 • ISBN-13: 978-0821869192 **f) Maß- und Integrationstheorie** • Autor: Heinz Bauer • Verlag: de Gruyter; Auflage: 2., überarb. A. (1. Juli 1992) • Sprache: Englisch • ISBN-10: 3110136252 • ISBN-13**:** 978-3110136258 **g) Maß- und Integrationstheorie** • Autor: Jürgen Elstrodt • Springer, 2004 • ISBN-10: 3540213902 • ISBN-13: 9783540213901

Course L1356: Higher Analysis	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
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 Data Science: Core Qualification: Compulsory Electrical Engineering: Core Qualification: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Logistics and Mobility: Core Qualification: Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Orientation Studies: Core Qualification: Elective Compulsory Naval Architecture: Core Qualification: Compulsory Technomathematics: Core Qualification: Compulsory Process Engineering: Core Qualification: Compulsory Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory

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

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

Module M1959: Seminar Technomathematics

Courses

Title	Typ	Hrs/wk	CP
Seminar: Technomathematics (L0920)	Seminar	2	4

Module Responsible	Prof. Anusch Taraz
Admission Requirements	None
Recommended Previous Knowledge	• Analysis & Linear Algebra I + II for Technomathematicians **or** • Mathematik I + II (for Engineering Students - German or English lecture series), **and** • an advanced course by the lecturer who is responsible for the seminar
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students acquire a deep understanding of the mathematical subject under consideration.
Skills	Students are able to • understand, analyze, classify and work on an advanced mathematical topic, • thoroughly study the recommended (and further) literature, • write down and present their results in a mathematically correct and comprehensible way.
Personal Competence	
Social Competence	Students are able to present their results in an appropriate way to the group.
Autonomy	Students are able to prepare a written scientific report on their own; in particular to • find and critically check relevant literature, • make and incorporate their own thoughts, • finish in time.
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Credit points	4
Course achievement	None
Examination	Presentation
Examination duration and scale	60 Minutes
Assignment for the Following Curricula	Technomathematics: Core Qualification: Compulsory

Course L0920: Seminar: Technomathematics

Typ	Seminar
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Dr. Christian Seifert, Dozenten der Mathematik, Dozenten des Fachbereiches Mathematik der UHH, Dr. Jens-Peter Zemke, Dr. Thibaut Lunet, Prof. Sabine Le Borne
Language	DE/EN
Cycle	WiSe/SoSe
Content	Selected topics from the fields • Applied Analysis • Computational mathematics • Discrete mathematics • Mathematical Optimization
Literature	wird in der Lehrveranstaltung bekannt gegeben

Specialization I. Mathematics

Module M1052: Algebra

Courses

Title	Typ	Hrs/wk	CP
Algebra (L1317)	Lecture	4	6
Algebra (L1318)	Recitation Section (small)	2	3

Module Responsible	Prof. Christoph Schweigert
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name the basic concepts in Algebra such as groups, rings and modules. 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 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1317: Algebra

Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	
Literature	• Jantzen, Schwermer, "Algebra" (Springer) • Artin, "Algebra" (Birkhäuser) • Bosch, "Algebra" (Springer) • Lang, "Algebra" (Springer)

Course L1318: Algebra	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0715: Solvers for Sparse Linear Systems

Courses

Title	Typ	Hrs/wk	CP
Solvers for Sparse Linear Systems (L0583)	Lecture	2	3
Solvers for Sparse Linear Systems (L0584)	Recitation Section (small)	2	3

Module Responsible	Prof. Sabine Le Borne
Admission Requirements	None
Recommended Previous Knowledge	• Mathematics I + II for Engineering students or Analysis & Lineare Algebra I + II for Technomathematicians • Programming experience in C
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can • list classical and modern iteration methods and their interrelationships, • repeat convergence statements for iterative methods, • explain aspects regarding the efficient implementation of iteration methods.
Skills	Students are able to • analyse, implement, test, and compare iterative methods, • analyse the convergence behaviour of iterative methods and, if applicable, compute congergence rates.
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 work on complex problems over an extended period of time, • 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	Oral exam
Examination duration and scale	20 min
Assignment for the Following Curricula	Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory Data Science: Core Qualification: Elective Compulsory Data Science: Specialisation I. Mathematics/Computer Science: Elective Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L0583: Solvers for Sparse Linear Systems

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	SoSe
Content	1. Sparse systems: Orderings and storage formats, direct solvers 2. Classical methods: basic notions, convergence 3. Projection methods 4. Krylov space methods 5. Preconditioning (e.g. ILU) 6. Multigrid methods 7. Domain Decomposition Methods
Literature	1. Y. Saad. Iterative methods for sparse linear systems 2. M. Olshanskii, E. Tyrtyshnikov. Iterative methods for linear systems: theory and applications

Course L0584: Solvers for Sparse Linear Systems	
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
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1056: Functional Analysis

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Functional Analysis (L1327)	Lecture	4	6
Functional Analysis (L1328)	Recitation Section (small)	2	3

Module Responsible	Prof. Reiner Lauterbach
Admission Requirements	None
Recommended Previous Knowledge	• Linear Algebra • Analysis
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name basic concepts in Functional Analysis such as Banach and Hilbert spaces, Baire's category theorem, Linear operators, dual spaces, classical function spaces, the Hahn-Banach theorem, (non-)compactness, the Spectrum and compact operators. 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 Functional Analysis 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1327: Functional Analysis	
Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	• Normed, Banach and Hilbert spaces • Baire's category theorem and implications (fundamental principles) • Linear operators, dual spaces • classical function spaces • Hahn-Banach theorem, (non-)compactness • Spectrum, compact operators
Literature	• Alt, **Lineare Funktionalanalysis -Eine anwendungsorientierte Einführung**, Springer, 2012 • Werner, **Funktionalanalysis**, Springer, 2011 • Rudin, **Functional analysis**, McGraw-Hill, 1973 • Adams, **Sobolev spaces**, Academic press, 1975

Course L1328: Functional Analysis	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0692: Approximation and Stability

Courses

Title	Typ	Hrs/wk	CP
Approximation and Stability (L0487)	Lecture	3	4
Approximation and Stability (L0488)	Recitation Section (small)	1	2

Module Responsible	Prof. Marko Lindner
Admission Requirements	None
Recommended Previous Knowledge	• Linear Algebra: systems of linear equations, least squares problems, eigenvalues, singular values • Analysis: sequences, series, differentiation, integration
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to • sketch and interrelate basic concepts of functional analysis (Hilbert space, operators), • name and understand concrete approximation methods, • name and explain basic stability theorems, • discuss spectral quantities, conditions numbers and methods of regularisation
Skills	Students are able to • apply basic results from functional analysis, • apply approximation methods, • apply stability theorems, • compute spectral quantities, • apply regularisation methods.
Personal Competence	
Social Competence	Students are able to solve specific problems in groups and to present their results appropriately (e.g. as a seminar presentation).
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 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** Yes; **Bonus** None; **Form** Presentation; **Description**
Examination	Oral exam
Examination duration and scale	20 min
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L0487: Approximation and Stability	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Marko Lindner
Language	DE/EN
Cycle	SoSe
Content	This course is about solving the following basic problems of Linear Algebra, • systems of linear equations, • least squares problems, • eigenvalue problems but now in function spaces (i.e. vector spaces of infinite dimension) by a stable approximation of the problem in a space of finite dimension. **Contents:** • crash course on Hilbert spaces: metric, norm, scalar product, completeness • crash course on operators: boundedness, norm, compactness, projections • uniform vs. strong convergence, approximation methods • applicability and stability of approximation methods, Polski's theorem • Galerkin methods, collocation, spline interpolation, truncation • convolution and Toeplitz operators • crash course on C*-algebras • convergence of condition numbers • convergence of spectral quantities: spectrum, eigen values, singular values, pseudospectra • regularisation methods (truncated SVD, Tichonov)
Literature	• R. Hagen, S. Roch, B. Silbermann: C*-Algebras in Numerical Analysis • H. W. Alt: Lineare Funktionalanalysis • M. Lindner: Infinite matrices and their finite sections

Course L0488: Approximation and Stability	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Marko Lindner
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1062: Mathematical Statistics

Courses

Title	Typ	Hrs/wk	CP
Mathematical Statistics (L1339)	Lecture	3	4
Mathematical Statistics (L1340)	Recitation Section (small)	1	2

Module Responsible	Prof. Natalie Neumeyer
Admission Requirements	None
Recommended Previous Knowledge	Mathematical Stochastics Measure Theory and Stochastics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge*	• Students can describe basic concepts in Mathematical Statistics such as the substitution and Maximum-Likelihood methods for construction of estimators, optimal unfalsified estimators, optimal tests for parametric probability distributions, sufficiency and completeness and their application to estimation and test problems, tests in normal distribution and confidence domains and test families. 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 Mathematical Statistics 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 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 minutes
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1339: Mathematical Statistics

Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	• Substitution and Maximum-Likelihood methods for construction of estimators • Optimal unfalsified estimators • Optimal tests for parametric probability distributions (Neymann-Pearson theory) • Sufficiency and completeness and their application to estimation and test problems • Tests in normal distribution (e.g. Student's test) • Confidence domains and test families
Literature	• V. K. Rohatgi and A. K. Ehsanes Saleh (2001). **An introduction to probability and statistics**. Wiley. • L. Wasserman (2010). **All of statistics : A concise course in statistical inference**. Springer. • H. Witting (1985). **Mathematische Statistik: Parametrische Verfahren bei festem Stichprobenumfang**. Teubner.

Course L1340: Mathematical Statistics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1429: Complex Functions

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Complex Functions (L1038)	Lecture	2	1
Complex Functions (L1042)	Recitation Section (large)	1	1
Complex Functions (L1041)	Recitation Section (small)	1	1

Module Responsible	Dozenten des Fachbereiches Mathematik der UHH
Admission Requirements	None
Recommended Previous Knowledge	Analysis, Higher Analysis, Linear Algebra
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students deepen their mathematics education through the comprehensive acquisition of knowledge in complex calculus.
Skills	Students possess the ability to use concepts and methods from this field, to classify and compare them, and to independently acquire further concepts from this field.
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 34, Study Time in Lecture 56
Credit points	3
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

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 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

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

Module M1079: Differential Geometry

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Differential Geometry (L1365)	Lecture	4	6
Differential Geometry (L1366)	Recitation Section (small)	2	3

Module Responsible	Prof. Vicente Cortés
Admission Requirements	None
Recommended Previous Knowledge	• Analysis • Higher Analysis
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts in Differential Geometry such as curves in Euclidean space, differentiable manifolds, hyperplanes in Euclidean space, surfaces, geodesy in Riemannian manifolds and Riemannian manifolds with constant curvature. 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 Differential Geometry 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1365: Differential Geometry

Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	• Curves in the Euclidean space • Introduction to differentiable manifolds • Hyperplanes in the Euclidean space • Surfaces • Geodesy in Riemannian manifolds • Riemannian manifolds with constant curvature
Literature	Manfredo Perdigão do Carmo: **Riemannian geometry**, Birkhäuser, 1992. Takashi Sakai, **Riemannian geometry**, AMS, 1996. Frank Warner, **Foundations of differentiable manifolds and Lie groups**, Springer, 1983.

Course L1366: Differential Geometry	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1080: Ordinary Differential Equations and Dynamical Systems

Courses

Title	Typ	Hrs/wk	CP
Ordinary Differential Equations and Dynamical Systems (L1367)	Lecture	4	6
Ordinary Differential Equations and Dynamical Systems (L1368)	Recitation Section (small)	2	3

Module Responsible	Prof. Reiner Lauterbach
Admission Requirements	None
Recommended Previous Knowledge	• Analysis • Higher Analysis
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts such as modelling with dynamical system, ordinary differential equations as dynamical systems, long time behavior of orbits, hyperbolic systems, linear differential equations and linearisations, structural stability and bifurcations, symbolic dynamic, Hamilton systems and ergodic systems. 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 Ordinary differential aquations and dynamical systems 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1367: Ordinary Differential Equations and Dynamical Systems	
Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	• Modelling with dynamical systems • Ordinary differential equations as dynamical systems (existence, uniqueness) • Long time behavior of orbits (predictibility, periodicity, stability, limit sets, attractors) • Hyperbolic systems, linear differential equations and linearisations • Structural stability and bifurcations • Symbolic dynamics • Hamilton systems, ergodic systems
Literature	• H. Amann, **Gewöhnliche Differentialgleichungen**, de Gruyter 1995 • C. Chicone, **Ordinary Differential Equations with Applications**, Springer 2006. • H. Heuser, **Gewöhnliche Differentialgleichungen**, Teubner 2009. • M. Hirsch, **S. Smale, R. Devaney, Differential equations, dynamical systems, and an introduction to chaos**, Elsevier 2004. • W. Walter, **Gewöhnliche Differentialgleichungen**, Springer 2000.

Course L1368: Ordinary Differential Equations and Dynamical Systems	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1060: Optimization

Courses

Title	Typ	Hrs/wk	CP
Optimization (L1333)	Lecture	4	6
Optimization (L1334)	Recitation Section (small)	2	3

Module Responsible	Prof. Armin Iske
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra Analysis
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts in Optimization such as conditions for optimality, globally convergent descent methods, locally fast convergent methods, locally and globally fast convergent methods, numerical methods and duality. 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 Optimization 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1333: Optimization	
Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe

Content	• real world Examples
	• non-restricted optimization
	  ◦ necessary and sufficient conditions for optimality
	  ◦ globally convergent descent methods, (e.g gradient methods, Trust-Region-methods)
	  ◦ locally fast convergentmethods (e.g. Newton and quasi-Newton-methods)
	  ◦ locally and globally fast convergent methods (e.g. globalised Newton-method)
	• restricted optimization
	  ◦ necessary and sufficient conditions for optimality
	  ◦ numerical methods (e.g. Penalty-method, SQP-method)
	  ◦ Selected topics (e.g. convex optimization, duality, parametric optimization)

Literature	• Ulbrich, M. and Ulbrich, S., **Nichtlineare Optimierung**, Verlag Birkhäuser Basel 2012 • C. Geiger and C. Kanzow, **Numerische Verfahren zur Lösung unrestringierter Optimierungsaufgaben**, Verlag Springer Berlin Heidelberg, 1999 • C. Geiger and C. Kanzow, **Theorie und Numerik restringierter Optimierungsaufgaben**, Verlag Springer Berlin Heidelberg, 2002 • J. Nocedal and S. J. Wright, **Numerical Optimization**, Verlag: Springer, 1999 • D. P. Bertsekas, **Nonlinear Programming,** Publisher: Athena Scientific,1999, 2nd Edition

Course L1334: Optimization	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0852: Graph Theory and Optimization

Courses

Title	Typ	Hrs/wk	CP
Graph Theory and Optimization (L1046)	Lecture	2	3
Graph Theory and Optimization (L1047)	Recitation Section (small)	2	3

Module Responsible	Prof. Anusch Taraz
Admission Requirements	None
Recommended Previous Knowledge	• Discrete Algebraic Structures • Mathematics I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name the basic concepts in Graph Theory and Optimization. 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 Graph Theory and Optimization 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 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Compulsory Logistics and Mobility: Specialisation Engineering Science: Elective Compulsory Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory Logistics and Mobility: Specialisation Information Technology: Elective Compulsory Technomathematics: Specialisation I. Mathematics: 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

Course L1046: Graph Theory and Optimization	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Anusch Taraz
Language	DE/EN
Cycle	SoSe
Content	• Graphs, search algorithms for graphs, trees • planar graphs • shortest paths • minimum spanning trees • maximum flow and minimum cut • theorems of Menger, König-Egervary, Hall • NP-complete problems • backtracking and heuristics • linear programming • duality • integer linear programming
Literature	• M. Aigner: Diskrete Mathematik, Vieweg, 2004 • T. Cormen, Ch. Leiserson, R. Rivest, C. Stein: Algorithmen - Eine Einführung, Oldenbourg, 2013 • J. Matousek und J. Nesetril: Diskrete Mathematik, Springer, 2007 • A. Steger: Diskrete Strukturen (Band 1), Springer, 2001 • A. Taraz: Diskrete Mathematik, Birkhäuser, 2012 • V. Turau: Algorithmische Graphentheorie, Oldenbourg, 2009 • K.-H. Zimmermann: Diskrete Mathematik, BoD, 2006

Course L1047: Graph Theory and Optimization	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Anusch Taraz
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1061: Measure Theory and Stochastics

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Measure Theory and Stochastics (L1335)	Lecture	3	4
Measure Theory and Stochastics (L1338)	Recitation Section (small)	1	2

Module Responsible	Prof. Holger Drees
Admission Requirements	None
Recommended Previous Knowledge	Mathematical Stochastics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts in Stochastics auch as general densities, conditional expectation, martingals in discrete time, convergence of probability measures and integral transformations. 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 Stochastics 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 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	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1335: Measure Theory and Stochastics

Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	• General densities, Radon-Nikodym theorem • Conditional expectation, Markov kernels • Martingals in discrete time • Convergence of probability measures • Integral transformations (e.g. generating functions, Fourier transformation, Laplace transformation)
Literature	• H. Bauer, **Maß- und Integrationstheorie**, de Gruyter Lehrbuch, Auflage: 2., überarb. A. (1. Juli 1992) • H. Bauer, **Wahrscheinlichkeitstheorie**, de Gruyter Lehrbuch, Verlag: de Gruyter; Auflage: 5. durchges. und verb. (2002) • J. Estrodt, **Maß- und Integrationstheorie**, Springer, 7., korrigierte und aktualisierte Auflage 2011

Course L1338: Measure Theory and Stochastics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0714: Numerical Methods for Ordinary Differential Equations

Courses

Title	Typ	Hrs/wk	CP
Numerical Treatment of Ordinary Differential Equations (L0576)	Lecture	2	3
Numerical Treatment of Ordinary Differential Equations (L0582)	Recitation Section (small)	2	3

Module Responsible	Prof. Daniel Ruprecht
Admission Requirements	None
Recommended Previous Knowledge	• Mathematik I, II, III für Ingenieurstudierende (deutsch oder englisch) oder Analysis & Lineare Algebra I + II sowie Analysis III für Technomathematiker • Basic knowledge of MATLAB, Python or a similar programming language
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to • list numerical methods for the solution of ordinary differential equations and explain their core ideas, • formulate convergence statements for the treated numerical methods (including the assumptions about the underlying problem), • explain aspects regarding the practical realisation of a method. • select the appropriate numerical method for concrete problems, implement the numerical algorithms efficiently and interpret the numerical results
Skills	Students are able to • implement, apply and compare numerical methods for the solution of ordinary differential equations, • justify the convergence behaviour of numerical methods with respect to the posed problem and selected algorithm, • develop a suitable solution approach for a given problem, if necessary by combining of several algorithms, and to realise this approach and critically evaluate the results.
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 progress 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 min
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Computer Science: Specialisation III. Mathematics: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Interdisciplinary Mathematics: Specialisation II. Numerical - Modelling Training: Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0576: Numerical Treatment of Ordinary Differential Equations	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Daniel Ruprecht
Language	DE/EN
Cycle	SoSe
Content	Numerical methods for Initial Value Problems • single step methods • multistep methods • stiff problems • differential algebraic equations (DAE) of index 1 Numerical methods for Boundary Value Problems • multiple shooting method • difference methods
Literature	• E. Hairer, S. Noersett, G. Wanner: Solving Ordinary Differential Equations I: Nonstiff Problems. • E. Hairer, G. Wanner: Solving Ordinary Differential Equations II: Stiff and Differential-Algebraic Problems. • D. Griffiths, D. Higham: Numerical Methods for Ordinary Differential Equations.

Course L0582: Numerical Treatment of Ordinary Differential Equations	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Daniel Ruprecht
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1083: Discrete Mathematics

Courses

Title	Typ	Hrs/wk	CP
Discrete Mathematics (L1379)	Lecture	4	6
Discrete Mathematics (L1380)	Recitation Section (small)	2	3

Module Responsible	Prof. Matthias Schacht
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra Geometry Analysis
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts in Discrete Mathematics such as elementary combinatorics and counting coefficients, sorting algorithms, graphs and network algorithms, complexity, asymptotic analysis, discrete probability distributions, generating functions, the principle of inclusion and exclusion, ordered sets, counting of trees and patterns and fundamentals in coding theory or cryptography. • 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 Combinatorics 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1379: Discrete Mathematics	
Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	• Introduction to discrete mathematics • Topics: ◦ Combinatorial problems and counting coefficients ◦ Sorting algorithms ◦ Fundamentals of graph theory ◦ Graph and Network algorithms ◦ Complexity ◦ Asymptotic analysiy ◦ Diskrete probability distributions ◦ Generating functions (ring of formal power series) ◦ Inclusion and exklusion principle ◦ oredered sets (Möbius inversion) ◦ Counting of trees and patterns ◦ Fundamentals in coding theory or cryptography
Literature	• M. Aigner: Diskrete Mathematik, Vieweg, 6., korr. Aufl. 2006 • L. Lovász, J. Pelikan & K. Vesztergombi Diskrete Mathematik, Springer, 2005 • J. Matoušek & J. Nešetřil: Diskrete Mathematik - Eine Entdeckungsreise, Springer, 2007 • A. Steger: Diskrete Strukturen - Band 1: Kombinatorik, Graphentheorie, Algebra, Springer, 2. Aufl. 2007 • A. Taraz: Diskrete Mathematik - Grundlagen und Methoden, Birkhäuser, 2012

Course L1380: Discrete Mathematics	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1958: Risk Theory

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Risk Theory (L3191)	Lecture	2	4
Risk Theory (L3192)	Recitation Section (small)	1	2

Module Responsible	Prof. Holger Drees
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 138, Study Time in Lecture 42
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L3191: Risk Theory

Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Holger Drees
Language	DE/EN
Cycle	WiSe
Content	
Literature	**Literatur**: Es wird ein ausführliches Skript zur Vorlesung jeweils kapitelweise im Vorhinein zur Verfügung gestellt werden. Ergänzende und weiterführende Literatur: • H. Föllmer und A. Schied (2011). Stochastic Finance (3rd ed.). De Gruyter. • R. Kaas, M. Goovaerts, J. Dhaene und M. Denuit (2008). Modern Actuarial Risk Theory (2nd ed.), Springer. • T. Mikosch (2003). Non-Life Insurance Mathematics: an Introduction with Stochastic Processes. Springer. • K.D. Schmidt (2002). Versicherungsmathematik. Springer. • B. Sundt (1994). An Introduction to Non-Life Insurance. Verlag Versicherungswirtschaft.

Course L3192: Risk Theory

Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Holger Drees
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1020: Numerical Methods for Partial Differential Equations

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Numerics of Partial Differential Equations (L1247)	Lecture	2	3
Numerics of Partial Differential Equations (L1248)	Recitation Section (small)	2	3

Module Responsible	Prof. Daniel Ruprecht
Admission Requirements	None
Recommended Previous Knowledge	• Mathematik I - IV (for Engineering Students) **or** Analysis & Linear Algebra I + II for Technomathematicians • Numerical mathematics 1 • Numerical methods for ordinary differential equations
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can classify partial differential equations according to the three basic types. • They know typical numerical methods like finite differences or finite volumes. • Students know the theoretical convergence results and other important properties of these methods.
Skills	Students are capable of formulating solution strategies for given partial differential equations, can comment on theoretical properties regarding convergence and are able to implement and test these methods.
Personal Competence	
Social Competence	Students are able of working together in heterogeneous teams (i.e., teams from different study programs and background knowledge) and to explain theoretical foundations.
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 mental stamina to work on hard problems for an extended period of time
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	Computer Science: Specialisation III. Mathematics: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L1247: Numerics of Partial Differential Equations

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Daniel Ruprecht
Language	DE/EN
Cycle	WiSe
Content	Elementary Theory and Numerics of PDEs • types of PDEs • well posed problems • finite differences • finite volumes • applications
Literature	Dale R. Durran: Numerical Methods for Fluid Dynamics. Randall J. LeVeque: Numerical Methods for Conservation Laws.

Course L1248: Numerics of Partial Differential Equations

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

Module M0881: Mathematical Image Processing

Courses

Title	Typ	Hrs/wk	CP
Mathematical Image Processing (L0991)	Lecture	3	4
Mathematical Image Processing (L0992)	Recitation Section (small)	1	2

Module Responsible	Prof. Marko Lindner
Admission Requirements	None
Recommended Previous Knowledge	• Analysis: partial derivatives, gradient, directional derivative • Linear Algebra: eigenvalues, least squares solution of a linear system
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to • characterize and compare diffusion equations • explain elementary methods of image processing • explain methods of image segmentation and registration • sketch and interrelate basic concepts of functional analysis
Skills	Students are able to • implement and apply elementary methods of image processing • explain and apply modern methods of image processing
Personal Competence	
Social Competence	Students are able to work together in heterogeneously composed teams (i.e., teams from different study programs and background knowledge) and to explain theoretical foundations.
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 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	20 min
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Computer Science: Specialisation III. Mathematics: Elective Compulsory Computer Science in Engineering: Specialisation III. Mathematics: Elective Compulsory Interdisciplinary Mathematics: Specialisation Computational Methods in Biomedical Imaging: Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0991: Mathematical Image Processing

Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Marko Lindner
Language	DE/EN
Cycle	WiSe
Content	• basic methods of image processing • smoothing filters • the diffusion / heat equation • variational formulations in image processing • edge detection • de-convolution • inpainting • image segmentation • image registration
Literature	Bredies/Lorenz: Mathematische Bildverarbeitung

Course L0992: Mathematical Image Processing	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Marko Lindner
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1552: Advanced Machine Learning

Courses

Title	Typ	Hrs/wk	CP
Advanced Machine Learning (L2322)	Lecture	2	3
Advanced Machine Learning (L2323)	Recitation Section (small)	2	3

Module Responsible	Dr. Jens-Peter Zemke
Admission Requirements	None
Recommended Previous Knowledge	1. Mathematics I-III 2. Numerical Mathematics 1/ Numerics 3. Programming skills, preferably in Python
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to name, state and classify state-of-the-art neural networks and their corresponding mathematical basics. They can assess the difficulties of different neural networks.
Skills	Students are able to implement, understand, and, tailored to the field of application, apply neural networks.
Personal Competence	
Social Competence	Students can • develop and document joint solutions in small teams; • form groups to further develop the ideas and transfer them to other areas of applicability; • form a team to develop, build, and advance a software library.
Autonomy	Students are able to • correctly assess the time and effort of self-defined work; • assess whether the supporting theoretical and practical excercises are better solved individually or in a team; • define test problems for testing and expanding the methods; • 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 min
Assignment for the Following Curricula	Computer Science: Specialisation III. Mathematics: Elective Compulsory Data Science: Core Qualification: Compulsory Computer Science in Engineering: Specialisation III. Mathematics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L2322: Advanced Machine Learning

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	WiSe
Content	1. Basics: analogy; layout of neural nets, universal approximation, NP-completeness 2. Feedforward nets: backpropagation, variants of Stochastic Gradients 3. Deep Learning: problems and solution strategies 4. Deep Belief Networks: energy based models, Contrastive Divergence 5. CNN: idea, layout, FFT and Winograds algorithms, implementation details 6. RNN: idea, dynamical systems, training, LSTM 7. ResNN: idea, relation to neural ODEs 8. Standard libraries: Tensorflow, Keras, PyTorch 9. Recent trends
Literature	1. Skript 2. Online-Werke: ◦ http://neuralnetworksanddeeplearning.com/ ◦ https://www.deeplearningbook.org/

Course L2323: Advanced Machine Learning	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0716: Hierarchical Algorithms

Courses

Title	Typ	Hrs/wk	CP
Hierarchical Algorithms (L0585)	Lecture	2	3
Hierarchical Algorithms (L0586)	Recitation Section (small)	2	3

Module Responsible	Prof. Sabine Le Borne
Admission Requirements	None
Recommended Previous Knowledge	• Mathematics I, II, III for Engineering students (german or english) or Analysis & Linear Algebra I + II as well as Analysis III for Technomathematicians • Programming experience in C
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to • name representatives of hierarchical algorithms and list their characteristics, • explain construction techniques for hierarchical algorithms, • discuss aspects regarding the efficient implementation of hierarchical algorithms.
Skills	Students are able to • implement the hierarchical algorithms discussed in the lecture, • analyse the storage and computational complexities of the algorithms, • adapt algorithms to problem settings of various applications and thus develop problem adapted variants.
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 work on complex problems over an extended period of time, • 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	Oral exam
Examination duration and scale	20 min
Assignment for the Following Curricula	Computer Science: Specialisation III. Mathematics: Elective Compulsory Data Science: Specialisation I. Mathematics: Elective Compulsory Data Science: Specialisation IV. Special Focus Area: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L0585: Hierarchical Algorithms

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	DE/EN
Cycle	WiSe
Content	• Low rank matrices • Separable expansions • Hierarchical matrix partitions • Hierarchical matrices • Formatted matrix operations • Applications • Additional topics (e.g. H2 matrices, matrix functions, tensor products)
Literature	W. Hackbusch: Hierarchische Matrizen: Algorithmen und Analysis

Course L0586: Hierarchical Algorithms	
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
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1063: Stochastic Processes

Courses

Title	Typ	Hrs/wk	CP
Stochastic Processes (L1343)	Lecture	3	4
Stochastic Processes (L1344)	Recitation Section (small)	1	2

Module Responsible	Prof. Holger Drees
Admission Requirements	None
Recommended Previous Knowledge	Mathematical Stochastics Measure Theory and Stochastics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts such as the classification and construction of stochastic processes, Markov processes with discrete state space in discrete and continuous time, renewal theory, general Markov processes and Markov semigroups, Poisson processes and Brownian motion. 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 Stochastic Processes 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 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	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1343: Stochastic Processes	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe
Content	• Classification and construction of stochastic processes, existence theorems • Markov processes with discrete state space in discrete and continuous time • Renewal theory • General Markov processes and Markov semigroups • Poisson processes, Brownian motion
Literature	• Asmussen, S.: Applied Probability and Queues, 2.ed., Springer, New York 2003 • Chung, K.L.: Markov Chains, 2.ed., Springer Berlin 1967 • Grimmett, G.; Stirzaker, D.R.: Probability and Random Processes, 3.ed., Oxford University Press, Oxford 2009 • Karlin, S.; Taylor, H.M.: A First Course in Stochastic Processes, 2.ed., Academic Press, New York 1975 • Resnick, S.I.: Adventures in Stochastic Processes, 2.pr., Birkhäuser, Boston 1994 • Stroock, D.W.: An Introduction to Markov Processes, Springer, New York 2005

Course L1344: Stochastic Processes	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1059: Approximation

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Approximation (L1331)	Lecture	4	6
Approximation (L1332)	Recitation Section (small)	2	3

Module Responsible	Prof. Armin Iske
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra Analysis Introduction to Numerical Analysis
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts in Approximation such as L^2 approximation, Tschebychev approximation and Remez methods, approximation of periodic functions, Fourier series, splines, representation of curves and surfaces, and wavelets and radial basis function. 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 Approximation 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1331: Approximation	
Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe
Content	• L^2 approximation • Tschebychev approximation and Remez methods • Approximation of periodic functions, Fourier series • Interpolation and approximation by splines • Representation of curves and surfaces • Wavelets and radial basis functions
Literature	• DeVore, Ronald A. und Lorentz, George G.: Constructive Approximation, Springer, 1993. • Powell, Michael J. D.: Approximation theory and methods, Cambridge University Press, 1981. • Cheney, Elliot W. und Light, William A.: A course in approximation theory, Brooks/Cole Publishing, 2000.

Course L1332: Approximation	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1058: Introduction to Mathematical Modeling

Courses

Title	Typ	Hrs/wk	CP
Introduction in Mathematical Modeling (L1329)	Lecture	4	6
Introduction in Mathematical Modeling (L1330)	Recitation Section (small)	2	3

Module Responsible	Prof. Ingenuin Gasser
Admission Requirements	None
Recommended Previous Knowledge	• Analysis • Linear Algebra
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts in Mathematical Modeling such as he modelling process, deterministic and stochastic models, modelling of dynamic processes, and discrete and continuous models. 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 Mathematical Modeling 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1329: Introduction in Mathematical Modeling	
Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe
Content	• The modelling process • deterministic and stochastic models • modelling of dynamic processes • discrete and continuous models
Literature	• C.P. Ortlieb, C. v. Dresky, I. Gasser, S. Günzel : Mathematische Modellierung - Eine Einführung in zwölf Fallstudien, 2. Auflage, Vieweg+Teubner (2012) • Richard Haberman : Mathematical Models: Mechanical Vibrations, Population Dynamics, and Traffic Flow. Classics in Mathematics 21, SIAM (1998). • C. C. Lin und L. A. Segal: Mathematics Applied to Deterministic Problems in the natural Sciences, SIAM (1988) • C. Eck, H. Garcke, P. Knabner: Mathematische Modellierung. Springer (2008)

Course L1330: Introduction in Mathematical Modeling	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1078: Geometry

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Geometry (L1363)	Lecture	4	6
Geometry (L1364)	Recitation Section (small)	2	3

Module Responsible	Prof. Alexander Kreuzer
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts in Geometry such as affine and projective planes and spaces, coordinatisation, collineations, fundamental theorems and applications of geometry. 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 Geometry 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1363: Geometry	
Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe
Content	• Affine and projective planes and spaces • Coordinatisation • Collineations • Fundamental theorems • Applications of geometry
Literature	1. M. Berger, **Geometry I**, Verlag: Springer, 1987 2. A. Beutelspacher und U. Rosenbaum, **Projektive Geometrie**, Verlag Vieweg, 1992 3. H. Brauner, **Geometrie projektiver Räume I, II**, BI, 1976 4. F. Buckenhout (Hrsg.), **Handbook of Incidence Geometry**, Verlag: Elsevier, 1995 5. R. Casse, **Projective Geometry: An Introduction**, Verlag: Oxford University Press, 2009 6. A. Herzer, **Geometrie I,II**, Skript, Universität Mainz, 1991/92 7. A. Holme, **Geometry: Our Cultural Heritage,** Verlag: Springer, 2002 8. D.R. Hughes und F.C. Piper, **Projective Planes**, Verlag: Springer, 1973 9. G.A. Jennings, **Modern Geometry with Applications**, Verlag: Springer, 1994 10. L. Kadison und M.T. Kromann, **Projective Geometry and Modern Algebra**, Verlag: Birkhäuser , 1996 11. H. Karzel und H.-J. Kroll, **Geschichte der Geometrie seit Hilbert**, Verlag: Wiss. Buchgesellschaft, 1988 12. H. Karzel, K. Sörensen und D. Windelberg, **Einführung in die Geometrie,** Verlag: Vandenhoeck und Rupprecht, 1973 13. H. Lenz, **Vorlesungen über projektive Geometrie**, Akad. Verl.-Ges., 1965 14. R. Lingenberg, **Grundlagen der Geometrie**, BI, 1978 15. E.M. Schröder, **Vorlesungen über Geometrie, II**, BI., 1991 16. C.J. Scriba und P. Schreiber, **5000 Jahre Geometrie,** Verlag: Springer, 2001 17. J. Ueberberg, **Foundations of Incidence Geometry: Projective and Polar Spaches**, Verlag: Springer, 2011

Course L1364: Geometry	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1129: Mathematical Systems Theory

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Mathematical Systems Theory (L1463)	Lecture	2	3
Mathematical Systems Theory (L1465)	Seminar	1	2
Mathematical Systems Theory (L1464)	Recitation Section (small)	1	1

Module Responsible	Prof. Timo Reis
Admission Requirements	None
Recommended Previous Knowledge	Analysis, Higher Analysis, Functional Analysis
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts in Mathematical Systems Theory such as controllability, stabilization by feedback, obervability, observer and controller design and linear-quadratic optimal control. 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 Mathematical Systems Theor 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 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	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1463: Mathematical Systems Theory

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	EN
Cycle	WiSe
Content	Systems Theory treats the mathematical background and foundations of the engineering discipline 'Cybernetics'. Thereby one wants to exert influence on a dynamical system (which is usually given by an ordinary differential equation (ODE)), such that a desired behavior is achieved. For instance, in classical mechanics, the motion of a mass point is determined by acting forces. In 'Systems and Control Theory', one wonders how these forces have to be chosen such that a prescribed movement of the mass point is accomplished. • Introduction and motivation • Controllability • Stabilization by feedback • Obervability • Observer and controller design • Linear-quadratic optimal control
Literature	• E.D. Sontag, Mathematical Control Theory: Deterministic Finite Dimensional Systems. Second Edition, Springer, New York, 1998 • T. Kailath, Linear Systems. Prentice-Hall, Englewood Cliffs, 1980 • H.W. Knobloch, H. Kwakernaak. Lineare Kontrolltheorie. Springer-Verlag, Berlin, 1985 • K. Zhou, J.C. Doyle, K. Glover. Robust and Optimal Control. Prentice Hall, Upper Saddle River, NJ, 1996

Course L1465: Mathematical Systems Theory	
Typ	Seminar
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1464: Mathematical Systems Theory	
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	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0941: Combinatorial Structures and Algorithms

Courses

Title	Typ	Hrs/wk	CP
Combinatorial Structures and Algorithms (L1100)	Lecture	3	4
Combinatorial Structures and Algorithms (L1101)	Recitation Section (small)	1	2

Module Responsible	Prof. Anusch Taraz
Admission Requirements	None
Recommended Previous Knowledge	• Mathematics I + II • Discrete Algebraic Structures • Graph Theory and Optimization
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name the basic concepts in Combinatorics and Algorithms. 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 Combinatorics and Algorithms 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 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	Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory Data Science: Core Qualification: Elective Compulsory Data Science: Specialisation I. Mathematics/Computer Science: Elective Compulsory Computer Science in Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1100: Combinatorial Structures and Algorithms	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Anusch Taraz, Dr. Dennis Clemens
Language	DE/EN
Cycle	WiSe
Content	• Counting • Structural Graph Theory • Analysis of Algorithms • Extremal Combinatorics • Random discrete structures
Literature	• M. Aigner: Diskrete Mathematik, Vieweg, 6. Aufl., 2006 • J. Matoušek & J. Nešetřil: Diskrete Mathematik - Eine Entdeckungsreise, Springer, 2007 • A. Steger: Diskrete Strukturen - Band 1: Kombinatorik, Graphentheorie, Algebra, Springer, 2. Aufl. 2007 • A. Taraz: Diskrete Mathematik, Birkhäuser, 2012.

Course L1101: Combinatorial Structures and Algorithms	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Anusch Taraz
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1050: Graph Theory

Courses

Title	Typ	Hrs/wk	CP
Graph Theory (L1311)	Lecture	4	6
Graph Theory (L1314)	Recitation Section (small)	2	3

Module Responsible	Prof. Reinhard Diestel
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts in Graph Theory such as connectivity, matchings, planarity, colourings, infinite graphs, spanning structures and Ramsey theory. 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 Graph Theory 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1311: Graph Theory

Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe
Content	Fundamentals of Graph Theory, important invariants and their relations Topics: • Matchings • Connectivity • Planar graphs • Graph coloring • Subgraphs and infinite Graphs • Ramsey theory • Hamilton cycles • Random graphs
Literature	• R.Diestel, **Graphentheorie** (4. Auflage), Springer 2010 • R.Diestel, **Graph Theory** (4th ed'n), GTM 173, Springer 2010/12

Course L1314: Graph Theory	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1051: Combinatorial Optimization

Courses

Title	Typ	Hrs/wk	CP
Combinatorial Optimization (L1315)	Lecture	4	6
Combinatorial Optimization (L1316)	Recitation Section (small)	2	3

Module Responsible	Prof. Matthias Schacht
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra, Discrete Mathematics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts in Combinatorial Optimization such as network algorithms, linear programming and duality, polyhedral combinatorics and NP-complexity theory 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 Combinatorial Optimization 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1315: Combinatorial Optimization	
Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe/SoSe

Content	Introduction to combinatorial optimization
	Topics:
	• Linear optimization: Polyhedra and LP Duality
	• Complexity of algorithms
	• polynomial algorithms for
	  ◦ minimal spanning trees
	  ◦ shortest paths
	  ◦ maximum flows and minimum cost flows
	  ◦ maximum matching and linear programs
	  ◦ polyhedral combinatorics for NP-hard problems (Knapsack, TSP, Clique Partioning)

Literature	• William J. Cook, William H. Cunningham, William R. Pulleyblank, Alexander Schrijver: Combinatorial Optimization. John Wiley & Sons, 1997 • Christos H. Papadimitriou, Kenneth Steiglitz: Combinatorial Optimization: Algorithms and Complexity. Dover Publications, 1998 • Eugene Lawler: Combinatorial Optimization: Networks and Matroids, Oxford University Press 1995

Course L1316: Combinatorial Optimization	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe/SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0720: Matrix Algorithms

Courses

Title	Typ	Hrs/wk	CP
Matrix Algorithms (L0984)	Lecture	2	3
Matrix Algorithms (L0985)	Recitation Section (small)	2	3

Module Responsible	Dr. Jens-Peter Zemke
Admission Requirements	None
Recommended Previous Knowledge	• Mathematics I - III • Numerical Mathematics 1/ Numerics • Basic knowledge of the programming languages Matlab and C
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to 1. name, state and classify state-of-the-art Krylov subspace methods for the solution of the core problems of the engineering sciences, namely, eigenvalue problems, solution of linear systems, and model reduction; 2. state approaches for the solution of matrix equations (Sylvester, Lyapunov, Riccati).
Skills	Students are capable to 1. implement and assess basic Krylov subspace methods for the solution of eigenvalue problems, linear systems, and model reduction; 2. assess methods used in modern software with respect to computing time, stability, and domain of applicability; 3. adapt the approaches learned to new, unknown types of problem.
Personal Competence	
Social Competence	Students can • develop and document joint solutions in small teams; • form groups to further develop the ideas and transfer them to other areas of applicability; • form a team to develop, build, and advance a software library.
Autonomy	Students are able to • correctly assess the time and effort of self-defined work; • assess whether the supporting theoretical and practical excercises are better solved individually or in a team; • define test problems for testing and expanding the methods; • 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	Oral exam
Examination duration and scale	25 min
Assignment for the Following Curricula	Computer Science: Specialisation III. Mathematics: Elective Compulsory Data Science: Specialisation IV. Special Focus Area: Elective Compulsory Data Science: Specialisation I. Mathematics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L0984: Matrix Algorithms	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	WiSe
Content	• Part A: Krylov Subspace Methods: ◦ Basics (derivation, basis, Ritz, OR, MR) ◦ Arnoldi-based methods (Arnoldi, GMRes) ◦ Lanczos-based methods (Lanczos, CG, BiCG, QMR, SymmLQ, PvL) ◦ Sonneveld-based methods (IDR, BiCGStab, TFQMR, IDR(s)) • Part B: Matrix Equations: ◦ Sylvester Equation ◦ Lyapunov Equation ◦ Algebraic Riccati Equation
Literature	Skript (224 Seiten) Ergänzend können die folgenden Lehrbücher herangezogen werden: 1. Saad, Yousef. Numerical methods for large eigenvalue problems: revised edition. Society for Industrial and Applied Mathematics, 2011. 2. Saad, Yousef. Iterative methods for sparse linear systems. Society for Industrial and Applied Mathematics, 2003. 3. Van der Vorst, Henk A. Iterative Krylov methods for large linear systems. No. 13. Cambridge University Press, 2003. 4. Liesen, Jörg, and Zdenek Strakos. Krylov subspace methods: principles and analysis. Oxford University Press, 2013.

Course L0985: Matrix Algorithms	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1592: Statistics

Courses

Title	Typ	Hrs/wk	CP
Statistics (L2430)	Lecture	3	4
Statistics (L2431)	Recitation Section (small)	1	2

Module Responsible	Prof. Matthias Schulte
Admission Requirements	None
Recommended Previous Knowledge	Stochastics (or a comparable class)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name the basic concepts in Statistics. 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.
Skills	• Students can model statistical problems with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods. They are able to use the statistical software R. • 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 (e.g. on their regular home work) in heterogeneously composed teams and to present their results appropriately (e.g. during exercise class). • 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 can put their knowledge in relation to the contents of other lectures. • 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 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Advanced Materials: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Computer Science: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Data Science: Compulsory Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory Data Science: Core Qualification: Compulsory Engineering Science: Specialisation Advanced Materials: Elective Compulsory Engineering Science: Specialisation Data Science: Compulsory Logistics and Mobility: Specialisation Information Technology: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Elective Compulsory

Course L2430: Statistics	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Matthias Schulte
Language	DE/EN
Cycle	WiSe
Content	• Multivariate distributions and stochastic convergence • Point estimators • Confidence intervals • Hypothesis testing • Nonparametric statistics • Linear Regression • Time series analysis • Statistical software (R)
Literature	• L. Dümbgen (2016): Einführung in die Statistik, Birkhäuser. • L. Dümbgen (2003): Stochastik für Informatiker, Springer. • H.-O. Georgii (2012): Stochastics: Introduction to Probability and Statistics, 2nd edition, De Gruyter. • N. Henze (2018): Stochastik für Einsteiger, 12th edition, Springer. • A. Klenke (2014): Probability Theory: A Comprehensive Course, 2nd edition, Springer. • U. Krengel (2005): Einführung in die Wahrscheinlichkeitstheorie und Statistik, 8th edition, Vieweg.

Course L2431: Statistics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Matthias Schulte
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0711: Numerical Mathematics II

Courses

Title	Typ	Hrs/wk	CP
Numerical Mathematics II (L0568)	Lecture	2	3
Numerical Mathematics II (L0569)	Recitation Section (small)	2	3

Module Responsible	Prof. Sabine Le Borne
Admission Requirements	None
Recommended Previous Knowledge	• Numerical Mathematics I • Python knowledge
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to • name advanced numerical methods for interpolation, approximation, integration, eigenvalue problems, eigenvalue problems, nonlinear root finding problems and explain their core ideas, • repeat convergence statements for the numerical methods, sketch convergence proofs, • explain practical aspects of numerical methods concerning runtime and storage needs • explain aspects regarding the practical implementation of numerical methods with respect to computational and storage complexity.
Skills	Students are able to • implement, apply and compare advanced numerical methods in Python, • justify the convergence behaviour of numerical methods with respect to the problem and solution algorithm and to transfer it to related problems, • for a given problem, develop a suitable solution approach, if necessary through composition of several algorithms, to execute this approach and to critically evaluate the results
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	Oral exam
Examination duration and scale	25 min
Assignment for the Following Curricula	Computer Science: Specialisation III. Mathematics: Elective Compulsory Data Science: Specialisation I. Mathematics: Elective Compulsory Data Science: Specialisation IV. Special Focus Area: Elective Compulsory Computer Science in Engineering: Specialisation III. Mathematics: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory

Course L0568: Numerical Mathematics II	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Sabine Le Borne, Dr. Jens-Peter Zemke
Language	DE/EN
Cycle	SoSe
Content	1. Error and stability: Notions and estimates 2. Rational interpolation and approximation 3. Multidimensional interpolation (RBF) and approximation (neural nets) 4. Quadrature: Gaussian quadrature, orthogonal polynomials 5. Linear systems: Perturbation theory of decompositions, structured matrices 6. Eigenvalue problems: LR-, QD-, QR-Algorithmus 7. Nonlinear systems of equations: Newton and Quasi-Newton methods, line search (optional) 8. Krylov space methods: Arnoldi-, Lanczos methods (optional)
Literature	• Skript • Stoer/Bulirsch: Numerische Mathematik 1, Springer • Dahmen, Reusken: Numerik für Ingenieure und Naturwissenschaftler, Springer

Course L0569: Numerical Mathematics II	
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	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1053: Introductory Number Theory

Courses

Title	Typ	Hrs/wk	CP
Number Theory (L1319)	Lecture	4	6
Number Theory (L1320)	Recitation Section (small)	2	3

Module Responsible	Prof. Ulf Kühn
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts in Number Theory such as congruences, quadratic remainders, ring of integers and diophantic problems. 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 Number Theory 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1319: Number Theory

Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe/SoSe
Content	• Congruences (chinese remainder theorem, Fermat's little problem, application to asymmetric cryptography) • Quadratic Remainders (Legendre symbol, quadratic reciprocity) • Properties of the ring of integers (units, ideals, classes of ideals) • Application to diophantic problems
Literature	• A. Beutelspacher, M.-A. Zschiegner: Diskrete Mathematik für Einsteiger. Vieweg • F. Ischebeck: Einladung zur Zahlentheorie. BI • J. Kramer: Zahlen für Einsteiger. Vieweg • K. Reiss, G. Schmieder: Basiswissen Zahlentheorie. Springer

Course L1320: Number Theory	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe/SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1086: Practical Statistics

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Practical Statistics (L1394)	Lecture	2	3
Practical Statistics (L1395)	Recitation Section (small)	1	2

Module Responsible	Prof. Natalie Neumeyer
Admission Requirements	None
Recommended Previous Knowledge	• Mathematical Stochastics • Mathematical Statistics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts in Practical Statistics such as nonparametric methods, linear models and multivariate methods. 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 Practical Statistics 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 108, Study Time in Lecture 42
Credit points	5
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1394: Practical Statistics

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe/SoSe
Content	• Nonparametric methods • Linear models • Multivariate methods
Literature	• P. Dalgaard, Introductory Statistics with R, Springer • J. Verzani, Using R for introductory statistics, Chapman & Hall • U. Ligges, Programmieren mit R, Springer

Course L1395: Practical Statistics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	WiSe/SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1054: Topology

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Topology (L1322)	Lecture	4	6
Topology (L1323)	Recitation Section (small)	2	3

Module Responsible	Prof. Birgit Richter
Admission Requirements	None
Recommended Previous Knowledge	• Linear Algebra • Analysis • Higher Analysis
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name basic concepts in Topology auch as metric and topological spaces, separation axioms, subspace, quotient and product topologies, connecticity and compactnes, homotopy, fundamental groups and covering spaces. 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 Topology 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1322: Topology	
Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe

Content	• set theoretic topology
	  ◦ metric and topological spaces
	  ◦ separation axiom
	  ◦ subspace, quotient and product topologies
	  ◦ connecticity
	  ◦ compactness
	• algebraic topology
	  ◦ homotopy
	  ◦ fundamental groups
	  ◦ covering spaces

Literature	• J. Munkres, **Topology - a first course**, Publisher: Prentice Hall College Div (June 1974) • B. v. Querenburg, **Mengentheoretische Topologie**, Verlag: Springer; Auflage: 3 (4. Oktober 2013) • G. Laures, M. Szymik, **Grundkurs Topologie**, Verlag: Spektrum Akademischer Verlag; Auflage: 2009 • K. Jänich, **Topologie**,Verlag**:** Springer; Auflage: 8. Aufl. 2005. 4., korr. Nachdruck 2008 • L.A. Steen, J.A. Seebach, Jr., **Counterexamples in Topology**, Publisher: Dover Publications (September 22, 1995) • O. Viro, O. Ivanov, N. Netsvetaev, V. Kharlamov, **Elementary Topology - Problem Textbook** , Publisher: American Mathematical Society (September 17, 2008) • A. Hatcher, **Algebraic Topology**, Verlag: Cambridge University Press (2002)

Course L1323: Topology	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1556: Set Theory and Mathematical Logic

Courses

Title	Typ	Hrs/wk	CP
Set Theory and Mathematical Logic (L2332)	Lecture	4	6
Set Theory and Mathematical Logic (L2333)	Recitation Section (small)	2	3

Module Responsible	Prof. Benedikt Loewe
Admission Requirements	None
Recommended Previous Knowledge	Linear Algebra
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts in Mathematical Logic and in Set Theory such as formal languages, predicate logic, the completeness theorem, the compactness theorem and the Löwenheim-Skolem theorems, Zermelo-Fraenkel axioms, ordinal- and cardinal numbers and the axiom of choice. 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 Mathematical Logic and in Set Theory 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L2332: Set Theory and Mathematical Logic

Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	• Foundations of mathematical logic and model theory • first order predicate logic • Gödel's completeness theorem and compactness theorem • Löwenheim-Skolem theorems • Foundations of set theory & Zermelo-Fraenkel axioms • Ordinal numbers and Cardinal numbers • Axiom of choice & equivalent formulations
Literature	Heinz-Dieter Ebbinghaus, Einführung in die Mengenlehre.

Course L2333: Set Theory and Mathematical Logic	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1668: Probability Theory

Courses

Title	Typ	Hrs/wk	CP
Probability Theory (L2643)	Lecture	3	4
Probability Theory (L2644)	Recitation Section (small)	1	2

Module Responsible	Prof. Matthias Schulte
Admission Requirements	None
Recommended Previous Knowledge	Familiarity with the basic concepts of probability
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name the basic concepts in probability theory. 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 from probability theory 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 explore and verify further logical connections between the concepts studied in the course. • For a given problem, the students can develop and execute a suitable technique, and are able to critically evaluate the results.
Personal Competence	
Social Competence	• Students are able to work together (e.g. on their regular home work) and to present their results appropriately (e.g. during exercise class). • 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 can put their knowledge in relation to the contents of other lectures. • 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 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	Computer Science: Specialisation III. Mathematics: Elective Compulsory Data Science: Specialisation IV. Special Focus Area: Elective Compulsory Data Science: Specialisation I. Mathematics: Elective Compulsory Interdisciplinary Mathematics: Specialisation II. Numerical - Modelling Training: Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L2643: Probability Theory	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Matthias Schulte
Language	EN
Cycle	SoSe
Content	• Measure and probability spaces • Integration and expectation • Types of stochastic convergence • Law of large numbers • Central limit theorem • Radon-Nikodym theorem • Conditional expectation • Martingales • Markov chains • Poisson processes
Literature	H. Bauer, Probability theory and elements of measure theory, second edition, Academic Press, 1981. A. Klenke, Probability Theory: A Comprehensive Course, second edition, Springer, 2014. G. F. Lawler, Introduction to Stochastic Processes, second edition, Chapman & Hall/CRC, 2006. A. N. Shiryaev, Probability, second edition, Springer, 1996.

Course L2644: Probability Theory	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Matthias Schulte
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1055: Complex Analysis

Courses

Title	Typ	Hrs/wk	CP
Complex Analysis (L1325)	Lecture	4	6
Complex Analysis (L1326)	Recitation Section (small)	2	3

Module Responsible	Prof. Vicente Cortés
Admission Requirements	None
Recommended Previous Knowledge	• Analysis • Higher Analysis
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts in Complex Analysis such as holomorphic functions, Cauchy's integral theorem and formula, the residue theorem, conformal maps, homology and homotopy versions of the residue theorem, analytic functions, Fourier series, harmonic functions, elliptic functions and integrals and the Gamma function. 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 Complex Analysis 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 186, Study Time in Lecture 84
Credit points	9
Course achievement	None
Examination	Oral exam
Examination duration and scale	30 min
Assignment for the Following Curricula	Technomathematics: Specialisation I. Mathematics: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory

Course L1325: Complex Analysis	
Typ	Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	• complex numbers, sequences and series of complex numbers (recapitulation) • real and complex differentiation of complex-valued functions, Wirtinger calculus • holomorphic functions • Cauchy's integral theorem, Cauchy's integral formula, residue theorem • determination of improper (real) integrals via complex methods • conformal maps • homology and homotopy versions of the residue theorem • Maximum principle • Counting of zeros and poles • Proofs of the fundamental theorem of algebra • analytic functions • Fourier series • harmonic functions • The Mittag-Leffler theorem and the Weierstraß factorization theorem • Elliptic funktions and integrals • Gamma function
Literature	• W. Fischer, I. Lieb, **Einführung in die komplexe Analysis**, Verlag**:** Vieweg+Teubner Verlag; Auflage: 2010 • Dietmar A. Salamon, **Funktionentheorie**, Verlag: Springer Basel; Auflage: 2012 • K. Fritzsche, **Grundkurs Funktionentheorie**, Verlag: Spektrum Akademischer Verlag; Auflage: 2009 • E. Freitag, R. Busam**, Funktionentheorie 1,** Verlag: Springer Berlin Heidelberg, 2002 • R. Remmert, G. Schumacher, **Funktionentheorie 1,** Verlag: Springer Berlin Heidelberg, 2002 • L.V. Ahlfors, **Complex Analysis**, Publisher**:** McGraw-Hill Science/Engineering/Math; 3 edition (January 1, 1979) • J.B. Conway, **Functions of one complex variable,** Springer, 1978

Course L1326: Complex Analysis	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dozenten des Fachbereiches Mathematik der UHH
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Specialization II. Informatics

Module M0732: Software Engineering

Courses

Title	Typ	Hrs/wk	CP
Software Engineering (L0627)	Lecture	2	3
Software Engineering (L0628)	Recitation Section (small)	2	3

Module Responsible	Prof. Sibylle Schupp
Admission Requirements	None
Recommended Previous Knowledge	• Automata theory and formal languages • Procedural programming or Functional programming • Object-oriented programming, algorithms, and data structures
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students explain the phases of the software life cycle, describe the fundamental terminology and concepts of software engineering, and paraphrase the principles of structured software development. They give examples of software-engineering tasks of existing large-scale systems. They write test cases for different test strategies and devise specifications or models using different notations, and critique both. They explain simple design patterns and the major activities in requirements analysis, maintenance, and project planning.
Skills	For a given task in the software life cycle, students identify the corresponding phase and select an appropriate method. They choose the proper approach for quality assurance. They design tests for realistic systems, assess the quality of the tests, and find errors at different levels. They apply and modify non-executable artifacts. They integrate components based on interface specifications.
Personal Competence	
Social Competence	Students practice peer programming. They explain problems and solutions to their peer. They communicate in English.
Autonomy	Using on-line quizzes and accompanying material for self study, students can assess their level of knowledge continuously and adjust it appropriately. Working on exercise problems, they receive additional feedback.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** Yes · **Bonus** 15 % · **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 Computer Science: Elective Compulsory Computer Science: Core Qualification: Compulsory Data Science: Specialisation I. Mathematics/Computer Science: Elective Compulsory Computer Science in Engineering: Specialisation I. Computer Science: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory

Course L0627: Software Engineering

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Sibylle Schupp
Language	EN
Cycle	SoSe
Content	• Model-based software engineering ◦ Information modeling (use case diagrams) ◦ Behavioral modeling (finite state machines, Petri Nets, behavioral UML diagrams) ◦ Structural modeling (OOA, UML class diagrams, OCL) ◦ Model-based testing • Engineering software products ◦ Agile processes ◦ Architecture ◦ Code-based testing ◦ System-level testing • Software management ◦ Maintenance ◦ Project management ◦ Software processes
Literature	Ian Sommerville, Engineering Software Products: An Introduction to Modern Software Engineering, Pearson 2020. Kassem A. Saleh, Software Engineering, J. Ross Publishing 2009.

Course L0628: Software Engineering	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Sibylle Schupp
Language	EN
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)	2	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 124, Study Time in Lecture 56
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 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 Mechanical Engineering: Elective Compulsory Engineering Science: Specialisation Mechatronics: Elective Compulsory Logistics and Mobility: Specialisation Information Technology: Elective Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective 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	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	See interlocking course
Literature	See interlocking course

Module M0624: Automata Theory and Formal Languages

Courses

Title	Typ	Hrs/wk	CP
Automata Theory and Formal Languages (L0332)	Lecture	2	4
Automata Theory and Formal Languages (L0507)	Recitation Section (small)	2	2

Module Responsible	Prof. Matthias Mnich
Admission Requirements	None
Recommended Previous Knowledge	Participating students should be able to - specify algorithms for simple data structures (such as, e.g., arrays) to solve computational problems - apply propositional logic and predicate logic for specifying and understanding mathematical proofs - apply the knowledge and skills taught in the module Discrete Algebraic Structures
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can explain syntax, semantics, and decision problems of propositional logic, and they are able to give algorithms for solving decision problems. Students can show correspondences to Boolean algebra. Students can describe which application problems are hard to represent with propositional logic, and therefore, the students can motivate predicate logic, and define syntax, semantics, and decision problems for this representation formalism. Students can explain unification and resolution for solving the predicate logic SAT decision problem. Students can also describe syntax, semantics, and decision problems for various kinds of temporal logic, and identify their application areas. The participants of the course can define various kinds of finite automata and can identify relationships to logic and formal grammars. The spectrum that students can explain ranges from deterministic and nondeterministic finite automata and pushdown automata to Turing machines. Students can name those formalism for which nondeterminism is more expressive than determinism. They are also able to demonstrate which decision problems require which expressivity, and, in addition, students can transform decision problems w.r.t. one formalism into decision problems w.r.t. other formalisms. They understand that some formalisms easily induce algorithms whereas others are best suited for specifying systems and their properties. Students can describe the relationships between formalisms such as logic, automata, or grammars.
Skills	Students can apply propositional logic as well as predicate logic resolution to a given set of formulas. Students analyze application problems in order to derive propositional logic, predicate logic, or temporal logic formulas to represent them. They can evaluate which formalism is best suited for a particular application problem, and they can demonstrate the application of algorithms for decision problems to specific formulas. Students can also transform nondeterministic automata into deterministic ones, or derive grammars from automata and vice versa. They can show how parsers work, and they can apply algorithms for the language emptiness problem in case of infinite words.
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 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Compulsory Engineering Science: Specialisation Mechatronics: Elective Compulsory Engineering Science: Specialisation Mechatronics: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechatronics: Elective Compulsory Computer Science in Engineering: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory

Course L0332: Automata Theory and Formal Languages	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Matthias Mnich
Language	EN
Cycle	SoSe
Content	1. Propositional logic, Boolean algebra, propositional resolution, SAT-2KNF 2. Predicate logic, unification, predicate logic resolution 3. Temporal Logics (LTL, CTL) 4. Deterministic finite automata, definition and construction 5. Regular languages, closure properties, word problem, string matching 6. Nondeterministic automata: Rabin-Scott transformation of nondeterministic into deterministic automata 7. Epsilon automata, minimization of automata, elimination of e-edges, uniqueness of the minimal automaton (modulo renaming of states) 8. Myhill-Nerode Theorem: Correctness of the minimization procedure, equivalence classes of strings induced by automata 9. Pumping Lemma for regular languages: provision of a tool which, in some cases, can be used to show that a finite automaton principally cannot be expressive enough to solve a word problem for some given language 10. Regular expressions vs. finite automata: Equivalence of formalisms, systematic transformation of representations, reductions 11. Pushdown automata and context-free grammars: Definition of pushdown automata, definition of context-free grammars, derivations, parse trees, ambiguities, pumping lemma for context-free grammars, transformation of formalisms (from pushdown automata to context-free grammars and back) 12. Chomsky normal form 13. CYK algorithm for deciding the word problem for context-free grammrs 14. Deterministic pushdown automata 15. Deterministic vs. nondeterministic pushdown automata: Application for parsing, LL(k) or LR(k) grammars and parsers vs. deterministic pushdown automata, compiler compiler 16. Regular grammars 17. Outlook: Turing machines and linear bounded automata vs general and context-sensitive grammars 18. Chomsky hierarchy 19. Mealy- and Moore automata: Automata with output (w/o accepting states), infinite state sequences, automata networks 20. Omega automata: Automata for infinite input words, Büchi automata, representation of state transition systems, verification w.r.t. temporal logic specifications (in particular LTL) 21. LTL safety conditions and model checking with Büchi automata, relationships between automata and logic 22. Fixed points, propositional mu-calculus 23. Characterization of regular languages by monadic second-order logic (MSO)
Literature	1. Logik für Informatiker Uwe Schöning, Spektrum, 5. Aufl. 2. Logik für Informatiker Martin Kreuzer, Stefan Kühling, Pearson Studium, 2006 3. Grundkurs Theoretische Informatik, Gottfried Vossen, Kurt-Ulrich Witt, Vieweg-Verlag, 2010. 4. Principles of Model Checking, Christel Baier, Joost-Pieter Katoen, The MIT Press, 2007

Course L0507: Automata Theory and Formal Languages	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Matthias Mnich
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1586: Scientific Programming

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Scientific Programming (L2405)	Lecture	3	4
Scientific Programming (L2406)	Recitation Section (small)	2	2

Module Responsible	Prof. Tobias Knopp
Admission Requirements	None
Recommended Previous Knowledge	procedural programming, linear algebra
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students • can efficiently solve scientific problems in a modern programming language. • are familiar with the concept of reproducible science. • can handle multidimensional arrays, sparse arrays, data frames and missing data. They know the advantages and disadvantages of specific data structures. • know various ways of presenting data, data relationships and error measures in a suitable way. They are familiar with known data formats for storing scientific data and can select a suitable format for specific data.
Skills	Students are able • to translate complex problems from a mathematical formulation into a suitable program. • to divide a complex problem into subproblems which can be implemented modularly. • to identify numerical standard problems and to use suitable standard algorithms which are available in libraries. • to write maintainable program code, the correctness of which is verified by suitable tests. • to measure the runtime of programs, to identify bottlenecks and to apply suitable acceleration techniques.
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	None
Examination	Subject theoretical and practical work
Examination duration and scale	exercise task, group project with presentation, and written test
Assignment for the Following Curricula	Computer Science: Specialisation I. Computer and Software Engineering: Elective Compulsory Data Science: Core Qualification: Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory

Course L2405: Scientific Programming

Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Tobias Knopp
Language	DE/EN
Cycle	SoSe
Content	• Elementary Data Types and the Relationship to Mathematics • Scientific data types: Multidimensional Arrays, sparse Arrays, Data Frames, Missing Data • Multiple Dispatch as an Efficient Paradigm for Scientific Programming • Literate Programming • Profiling and benchmarks • Acceleration techniques: caching, multi-threading, SIMD, GPGPU • Scientific data formats: CSV, TOML, HDF5, and selected examples • Data visualization • Standard numerical techniques and efficient program libraries (BLAS, LAPACK, FFTW, ...) • Tests, code management, documentation • Reproducible science
Literature	Ben Lauwens, Allen Downey: Think Julia: How to Think Like a Computer Scientist

Course L2406: Scientific Programming	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Tobias Knopp
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0730: Computer Engineering

Courses

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

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

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

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

Module M0834: Computernetworks and Internet Security

Courses

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

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

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

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

Module M1423: Algorithms and Data Structures

Courses

Title	Typ	Hrs/wk	CP
Algorithms and Data Structures (L2046)	Lecture	4	4
Algorithms and Data Structures (L2047)	Recitation Section (small)	1	2

Module Responsible	Prof. Matthias Mnich
Admission Requirements	None
Recommended Previous Knowledge	• Discrete Algebraic Structures • Mathematics I • Mathematics II • Procedual Programming • Objectoriented Programming
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can name the basic concepts in algorithm design, algorithm analysis and problem reductions. 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 discrete decision, search and optimization problems with the help of the concepts studied in this course. Moreover, they are capable of solving them, and reducing them to each other, 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 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 Computer Science: Compulsory General Engineering Science (German program, 7 semester): Specialisation Data Science: Compulsory Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Compulsory Engineering Science: Specialisation Data Science: Compulsory Computer Science in Engineering: Core Qualification: Compulsory Logistics and Mobility: Specialisation Information Technology: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Elective Compulsory

Course L2046: Algorithms and Data Structures	
Typ	Lecture
Hrs/wk	4
CP	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Matthias Mnich
Language	DE/EN
Cycle	WiSe
Content	• Insertion sort • Register machines • Asymptotic analysis, Landau notation • Polynomial-time algorithms and NP-completeness • Divide-and-conquer, merge sort • Strassen algorithm • Greedy algorithm • Dynamic programming • Quick sort • AVL-trees, B-trees • Hashing • Depth first search, breadth first search • Shortest paths • Flow problems, Ford-Fulkerson algorithm
Literature	• T. Cormen, Ch. Leiserson, R. Rivest, C. Stein: Introduction to Algorithms. MIT Press, 2013 • S. Skiena: The Algorithm Design Manual. Springer, 2008 • J. M. Kleinberg and É. Tardos. Algorithm Design. Addison-Wesley, 2005.

Course L2047: Algorithms and Data Structures	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Matthias Mnich
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0625: Databases

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Databases (L0337)	Lecture	3	4
Databases - Exercise (L1150)	Recitation Section (small)	2	2

Module Responsible	Prof. Stefan Schulte
Admission Requirements	None
Recommended Previous Knowledge	Students should have basic knowledge in the following areas: • Discrete Algebraic Structures • Procedural Programming • Automata Theory and Formal Languages • Programming Paradigms
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of the course, students know: • Introduction to database systems • Design instruments for relational databases, especially entity-relationship • The relational model • Relational query languages, especially SQL • Normalization • Physical data organization • Transaction management • Query optimization • Data representation • Object-oriented and object-relational databases • Paradigms and concepts of current technologies for data modelling and database systems
Skills	The students acquire the ability to model a database and to work with it. This comprises especially the application of design methodologies and query and definition languages. Furthermore, students are able to apply basic functionalities needed to run a database.
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	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Data Science: Compulsory Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Compulsory Engineering Science: Specialisation Data Science: Compulsory Computer Science in Engineering: Specialisation I. Computer Science: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory

Course L0337: Databases	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Stefan Schulte
Language	EN
Cycle	WiSe
Content	• Introduction to database systems • Design instruments for relational databases, especially entity-relationship • The relational model • Relational query languages, especially SQL • Normalization • Physical data organization • Transaction management • Query optimization • Data representation • Object-oriented and object-relational databases • Paradigms and concepts of current technologies for data modelling and database systems
Literature	• A. Kemper, A. Eickler, Datenbanksysteme, 10. Auflage, De Gruyter, Oldenbourg, 2015 • R. Elmasri, S. B. Navathe, Fundamentals of Database Systems, 7th edition, Pearson, 2016

Course L1150: Databases - Exercise	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Stefan Schulte
Language	EN
Cycle	WiSe
Content	• Introduction to database systems • Design instruments for relational databases, especially entity-relationship • The relational model • Relational query languages, especially SQL • Normalization • Physical data organization • Transaction management • Query optimization • Data representation • Object-oriented and object-relational databases • Paradigms and concepts of current technologies for data modelling and database systems
Literature	• A. Kemper, A. Eickler, Datenbanksysteme, 10. Auflage, De Gruyter, Oldenbourg, 2015 • R. Elmasri, S. B. Navathe, Fundamentals of Database Systems, 7th edition, Pearson, 2016

Module M0731: Functional Programming

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Functional Programming (L0624)	Lecture	2	2
Functional Programming (L0625)	Recitation Section (large)	2	2
Functional Programming (L0626)	Recitation Section (small)	2	2

Module Responsible	Prof. Sibylle Schupp
Admission Requirements	None
Recommended Previous Knowledge	Discrete mathematics at high-school level
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students apply the principles, constructs, and simple design techniques of functional programming. They demonstrate their ability to read Haskell programs and to explain Haskell syntax as well as Haskell's read-eval-print loop. They interpret warnings and find errors in programs. They apply the fundamental data structures, data types, and type constructors. They employ strategies for unit tests of functions and simple proof techniques for partial and total correctness. They distinguish laziness from other evaluation strategies.
Skills	Students break a natural-language description down in parts amenable to a formal specification and develop a functional program in a structured way. They assess different language constructs, make conscious selections both at specification and implementations level, and justify their choice. They analyze given programs and rewrite them in a controlled way. They design and implement unit tests and can assess the quality of their tests. They argue for the correctness of their program.
Personal Competence	
Social Competence	Students practice peer programming with varying peers. They explain problems and solutions to their peer. They defend their programs orally. They communicate in English.
Autonomy	In programming labs, students learn under supervision (a.k.a. "Betreutes Programmieren") the mechanics of programming. In exercises, they develop solutions individually and independently, and receive feedback.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	**Compulsory** Yes · **Bonus** 15 % · **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 Computer Science: Elective Compulsory Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Elective Compulsory Data Science: Specialisation I. Mathematics/Computer Science: Elective Compulsory Engineering Science: Specialisation Mechatronics: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechatronics: Elective Compulsory Computer Science in Engineering: Specialisation I. Computer Science: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory

Course L0624: Functional Programming

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Sibylle Schupp
Language	EN
Cycle	WiSe
Content	• Functions, Currying, Recursive Functions, Polymorphic Functions, Higher-Order Functions • Conditional Expressions, Guarded Expressions, Pattern Matching, Lambda Expressions • Types (simple, composite), Type Classes, Recursive Types, Algebraic Data Type • Type Constructors: Tuples, Lists, Trees, Associative Lists (Dictionaries, Maps) • Modules • Interactive Programming • Lazy Evaluation, Call-by-Value, Strictness • Design Recipes • Testing (axiom-based, invariant-based, against reference implementation) • Reasoning about Programs (equation-based, inductive) • Idioms of Functional Programming • Haskell Syntax and Semantics
Literature	Graham Hutton, Programming in Haskell, Cambridge University Press 2007.

Course L0625: Functional Programming	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Sibylle Schupp
Language	EN
Cycle	WiSe
Content	• Functions, Currying, Recursive Functions, Polymorphic Functions, Higher-Order Functions • Conditional Expressions, Guarded Expressions, Pattern Matching, Lambda Expressions • Types (simple, composite), Type Classes, Recursive Types, Algebraic Data Type • Type Constructors: Tuples, Lists, Trees, Associative Lists (Dictionaries, Maps) • Modules • Interactive Programming • Lazy Evaluation, Call-by-Value, Strictness • Design Recipes • Testing (axiom-based, invariant-based, against reference implementation) • Reasoning about Programs (equation-based, inductive) • Idioms of Functional Programming • Haskell Syntax and Semantics
Literature	Graham Hutton, Programming in Haskell, Cambridge University Press 2007.

Course L0626: Functional Programming	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Sibylle Schupp
Language	EN
Cycle	WiSe
Content	• Functions, Currying, Recursive Functions, Polymorphic Functions, Higher-Order Functions • Conditional Expressions, Guarded Expressions, Pattern Matching, Lambda Expressions • Types (simple, composite), Type Classes, Recursive Types, Algebraic Data Type • Type Constructors: Tuples, Lists, Trees, Associative Lists (Dictionaries, Maps) • Modules • Interactive Programming • Lazy Evaluation, Call-by-Value, Strictness • Design Recipes • Testing (axiom-based, invariant-based, against reference implementation) • Reasoning about Programs (equation-based, inductive) • Idioms of Functional Programming • Haskell Syntax and Semantics
Literature	Graham Hutton, Programming in Haskell, Cambridge University Press 2007.

Module M1594: Machine Learning II

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Machine Learning II (L2436)	Lecture	2	3
Machine Learning II (L2941)	Recitation Section (small)	3	3

Module Responsible	Prof. Nihat Ay
Admission Requirements	None
Recommended Previous Knowledge	Successful participation in the modules: • Scientific Programming • Algorithms and Data Structures • Machine Learning
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students get to know tools used by development teams to • plan development flows, • mine, process and analyze data • train and validate data-orientated models • follow good practice in software engineering
Skills	Students work in teams on a larger data project. The required competences are learned and practically applied. These are for example: • project specification based on user requirements • creating a data-orientated software architecture • mining, preprocessing and analyzing larger datasets • implementing a learning platform in a team • comparison of different learning methods • performing statistical tests
Personal Competence	
Social Competence	Team work has its own challenges with respect to interaction of team members as well as finding the necessary agreement during joint software development. During the project students learn the required competences and experience the practical needs.
Autonomy	During team work it is mandatory to take and explain a certain position, to independently complete assigned tasks, and to present results to the team. Open issues must be identified and returned into the team to find an agreed resolution.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** No / 20 % / Excercises /
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Data Science: Elective Compulsory Data Science: Core Qualification: Compulsory Engineering Science: Specialisation Data Science: Elective Compulsory Mechatronics: Specialisation Dynamic Systems and AI: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory

Course L2436: Machine Learning II	
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	WiSe
Content	• Supervised statistical learning and generalisation • The empirical risk minimisation principle • The law of large numbers and the Glivenko-Cantellit heorem • Shatter coefficients, VC dimension, and Rademacher complexity • Fast convergence theorem of Vapnik and Chervonenkis • VC dimensions of discrete neural networks • The structural risk minimisation principle • Learning from samples as an inverse problem • Reproducing kernel Hilbert space • Moore-Penrose inverse • Ill-posed inverse problems and regularisation • Tikhonov regularisation • Regularised empirical risk minimisation • covering numbers • The bias variance problem
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 L2941: Machine Learning II	
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	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1593: Data Mining

Courses

Title	Typ	Hrs/wk	CP
Data Mining (L2434)	Lecture	2	3
Data Mining (L2435)	Project-/problem-based Learning	2	3

Module Responsible	Prof. Stefan Schulte
Admission Requirements	None
Recommended Previous Knowledge	• Databases • Machine learning
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of the course, students know: • Basic concepts for data preparation • Similarity and distance measures • Methods to mine data patterns • Procedures to analyse clusters • Approaches to identify outliers • Data mining for different types of data, e.g., data streams, text data, time series data
Skills	Students are able to analyze large, heterogeneous volumes of data. They know methods and their application to recognize patterns in data sets and data clusters. The students are able to apply the studied methods in different domains, e.g., for data streams, text data, or time series data.
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 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory**: Yes; **Bonus**: 20 %; **Form**: Subject theoretical and practical work; **Description**: Praktische Arbeiten zu bestimmten Themen aus dem Bereich Data Mining
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	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 Data Science: Compulsory Logistics and Mobility: Specialisation Information Technology: Elective Compulsory Mechatronics: Specialisation Dynamic Systems and AI: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory Engineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Elective Compulsory

Course L2434: Data Mining

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Stefan Schulte, Dr. Dominik Schallmoser
Language	EN
Cycle	WiSe
Content	• Data preparation • Similarity and distance measures • Pattern mining • Cluster analysis • Outliers detection • Data mining for different types of data, e.g., data streams, text data, time series data
Literature	Charu C. Aggarwal: Text Mining - The Textbook, Springer, 2015. Available at https://link.springer.com/book/10.1007/978-3-319-14142-8

Course L2435: Data Mining	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Stefan Schulte, Dr. Dominik Schallmoser
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1883: Introduction to Quantum Computing

Courses

Title	Typ	Hrs/wk	CP
Introduction to Quantum Computing (L3109)	Lecture	2	3
Introduction to Quantum Computing (L3110)	Recitation Section (large)	2	3

Module Responsible	Prof. Martin Kliesch
Admission Requirements	None
Recommended Previous Knowledge	• Linear algebra and very good mathematical skills • Prior knowledge in theoretical computer science or quantum mechanics is helpful but not required
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Information theoretic understanding of quantum mechanics • The quantum teleportation protocol • Basic quantum algorithms • Grover's search algorithm • The quantum Fourier transform and Shor's algorithm for integer factoring • The unitary circuit model of quantum computation (qubits, quantum gates and readout) and the complexity class BQP
Skills	• Rigorous understanding of how quantum algorithms work and the ability to analyze them • Connection of concepts in quantum mechanics and computer science • Basic knowledge required to start programming a quantum computer • Ability to solve exercises related to quantum algorithms
Personal Competence	
Social Competence	After completing this module, students are expected to be able to work on subject-specific tasks alone or in a group and to present the results appropriately. Moreover, students will be trained to identify and defuse misleading statements related to quantum computing, which can often be found in popular media.
Autonomy	After completion of this module, students are able to work out sub-areas of the subject independently using textbooks and other literature, to summarize and present the acquired knowledge and to link it to the contents of other courses.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** Yes / 20 % / Excercises /
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Elective Compulsory Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory Computer Science in Engineering: Specialisation I. Computer Science: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory

Course L3109: Introduction to Quantum Computing

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Martin Kliesch
Language	DE/EN
Cycle	WiSe
Content	Quantum computing is among the most exciting applications of quantum mechanics. Quantum algorithms can solve computational problems efficiently that have a prohibitive runtime on traditional computers. Such problems include, for instance, factoring of integer numbers or energy estimation problems from quantum chemistry and material science. This course provides an introduction to the topic. An emphasize will be put on conceptual and mathematical aspects.
Literature	• Course specific lecture notes will be provided • Nielsen and Chuang, Quantum Computation and Quantum Information • Sevag Gharibian's lecture notes

Course L3110: Introduction to Quantum Computing	
Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Martin Kliesch
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1249: Medical Imaging

Courses

Title	Typ	Hrs/wk	CP
Medical Imaging (L1694)	Lecture	2	3
Medical Imaging (L1695)	Recitation Section (small)	2	3

Module Responsible	Prof. Tobias Knopp
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in linear algebra, numerics, and signal processing
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of the module, students are able to describe reconstruction methods for different tomographic imaging modalities such as computed tomography and magnetic resonance imaging. They know the necessary basics from the fields of signal processing and inverse problems and are familiar with both analytical and iterative image reconstruction methods. The students have a deepened knowledge of the imaging operators of computed tomography and magnetic resonance imaging.
Skills	The students are able to implement reconstruction methods and test them using tomographic measurement data. They can visualize the reconstructed images and evaluate the quality of their data and results. In addition, students can estimate the temporal complexity of imaging algorithms.
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 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	Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Data Science: Specialisation III. Applications: Elective Compulsory Data Science: Specialisation IV. Special Focus Area: Elective Compulsory Electrical Engineering: Specialisation Medical Technology: Elective Compulsory Computer Science in Engineering: Specialisation I. Computer Science: Elective Compulsory Interdisciplinary Mathematics: Specialisation Computational Methods in Biomedical Imaging: Compulsory Microelectronics and Microsystems: Specialisation Communication and Signal Processing: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

Course L1694: Medical Imaging

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Tobias Knopp
Language	DE/EN
Cycle	WiSe
Content	• Overview about different imaging methods • Signal processing • Inverse problems • Computed tomography • Magnetic resonance imaging • Compressed Sensing • Magnetic particle imaging
Literature	**Bildgebende Verfahren in der Medizin**; O. Dössel; Springer, Berlin, 2000 **Bildgebende Systeme für die medizinische Diagnostik**; H. Morneburg (Hrsg.); Publicis MCD, München, 1995 **Introduction to the Mathematics of Medical Imaging**; C. L.Epstein; Siam, Philadelphia, 2008 **Medical Image Processing, Reconstruction and Restoration**; J. Jan; Taylor and Francis, Boca Raton, 2006 **Principles of Magnetic Resonance Imaging**; Z.-P. Liang and P. C. Lauterbur; IEEE Press, New York, 1999

Course L1695: Medical Imaging	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Tobias Knopp
Language	DE/EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0668: Algebra and Control

Courses

Title	Typ	Hrs/wk	CP
Algebra and Control (L0428)	Lecture	2	4
Algebra and Control (L0429)	Recitation Section (small)	2	2

Module Responsible	Dr. Prashant Batra
Admission Requirements	None
Recommended Previous Knowledge	Basics of Real Analysis and Linear Algebra of Vector Spaces and either of: Introduction to Control Theory or: Discrete Mathematics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can • Describe input-output systems polynomially • Explain factorization approaches to transfer functions • Name stabilization conditions for systems in coprime stable factorization.
Skills	Students are able to • Undertake a synthesis of stable control loops • Apply suitable methods of analysis and synthesis to describe all stable control loops • Ensure the fulfillment of specified performance measurements.
Personal Competence	
Social Competence	After completing the module, students are able to solve subject-related tasks and to present the results.
Autonomy	Students are provided with tasks which are exam-related so that they can examine their learning progress and reflect on it.
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	Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory

Course L0428: Algebra and Control	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Dr. Prashant Batra
Language	DE/EN
Cycle	SoSe
Content	- Algebraic control methods, polynomial and fractional approach -Single input - single output (SISO) control systems synthesis by algebraic methods, - Simultaneous stabilization - Parametrization of all stabilizing controllers - Selected methods of pole assignment. - Filtering and sensitivity minimization - Polynomial matrices, left and right polynomial fractions. - Euclidean algorithm, diophantine equations over rings - Smith-McMillan normal form - Multiple input - multiple output control system synthesis by polynomial methods, condition of stability.
Literature	• Vidyasagar, M.: Control system synthesis: a factorization approach. The MIT Press,Cambridge/Mass. - London, 1985. • Vardulakis, A.I.G.: Linear multivariable control. Algebraic analysis and synthesis methods, John Wiley & Sons,Chichester,UK,1991. • Chen, Chi-Tsong: Analog and digital control system design. Transfer-function, state-space, and algebraic methods. Oxford Univ. Press,1995. • Kučera, V.: Analysis and Design of Discrete Linear Control Systems. Praha: Academia, 1991.

Course L0429: Algebra and Control	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Prashant Batra
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0754: Compiler Construction

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Compiler Construction (L0703)	Lecture	2	2
Compiler Construction (L0704)	Recitation Section (small)	2	4

Module Responsible	Prof. Sibylle Schupp
Admission Requirements	None
Recommended Previous Knowledge	• Practical programming experience • Automata theory and formal languages • Functional programming or procedural programming • Object-oriented programming, algorithms, and data structures • Basic knowledge of software engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students explain the workings of a compiler and break down a compilation task in different phases. They apply and modify the major algorithms for compiler construction and code improvement. They can re-write those algorithms in a programming language, run and test them. They choose appropriate internal languages and representations and justify their choice. They explain and modify implementations of existing compiler frameworks and experiment with frameworks and tools.
Skills	Students design and implement arbitrary compilation phases. They integrate their code in existing compiler frameworks. They organize their compiler code properly as a software project. They generalize algorithms for compiler construction to algorithms that analyze or synthesize software.
Personal Competence	
Social Competence	Students develop the software in a team. They explain problems and solutions to their team members. They present and defend their software in class. They communicate in English.
Autonomy	Students develop their software independently and define milestones by themselves. They receive feedback throughout the entire project. They organize the software project so that they can assess their progress themselves.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Software (Compiler)
Assignment for the Following Curricula	Computer Science: Specialisation I. Computer and Software Engineering: Elective Compulsory Computer Science in Engineering: Specialisation I. Computer Science: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory

Course L0703: Compiler Construction

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Sibylle Schupp
Language	EN
Cycle	SoSe
Content	• Lexical and syntactic analysis • Semantic analysis • High-level optimization • Intermediate languages and code generation • Compilation pipeline
Literature	Alfred Aho, Jeffrey Ullman, Ravi Sethi, and Monica S. Lam, Compilers: Principles, Techniques, and Tools, 2nd edition Aarne Ranta, Implementing Programming Languages, An Introduction to Compilers and Interpreters, with an appendix coauthored by Markus Forsberg, College Publications, London, 2012

Course L0704: Compiler Construction

Typ	Recitation Section (small)
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Sibylle Schupp
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0562: Computability and Complexity Theory

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Computability and Complexity Theory (L0166)	Lecture	2	3
Computability and Complexity Theory (L0167)	Recitation Section (small)	2	3

Module Responsible	Prof. Martin Kliesch
Admission Requirements	None
Recommended Previous Knowledge	Discrete Algebraic Structures, Automata Theory, Logic, and Formal Language Theory
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Basic models of computation (finite state machines, Turing machines) • Decision problems and formal languages • Gödel numbering of computations • Universal computability • Decidable and undecidable problems • Reductions, diagonalization, Rice's theorem • Time and space complexity • The complexity classes P and NP • Hierarchy theorems • Polynomial time reductions, NP-completeness • Cook-Levin theorem • Uniform circuit families
Skills	After completing this module, students are able to • reproduce the knowledge taught in the course, • reproduce simpler proofs of the course and reproduce the ideas of the more complicated ones, • establish connections between the concepts taught, and • apply the learned knowledge to concrete problems.
Personal Competence	
Social Competence	After completing this module, students are able to work on subject-specific tasks alone or in a group and to present the results appropriately.
Autonomy	After completion of this module, students are able to work out sub-areas of the subject area independently on the basis of textbooks and other literature, to summarize and present the acquired knowledge and to link it to the contents of other courses.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** Yes — **Bonus** 15 % — **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 Computer Science: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Data Science: Elective Compulsory Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Elective Compulsory Data Science: Specialisation I. Mathematics/Computer Science: Elective Compulsory Computer Science in Engineering: Specialisation I. Computer Science: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory

Course L0166: Computability and Complexity Theory

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Martin Kliesch
Language	DE/EN
Cycle	SoSe
Content	
Literature	

Course L0167: Computability and Complexity Theory	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Martin Kliesch
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1812: Constraint Satisfaction Problems

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Constraint Satisfaction Problems (L3002)	Lecture	2	3
Constraint Satisfaction Problems (L3003)	Recitation Section (large)	2	3

Module Responsible	Prof. Antoine Mottet
Admission Requirements	None
Recommended Previous Knowledge	The students should have followed the courses Complexity Theory, Discrete Algebraic Structures, Linear Algebra.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can describe basic concepts from the theory of constraint satisfaction such as primitive positive formulas, interpretations, polymorphisms, clones • Students can discuss the connections between these concepts • Students know proofs strategies and can reproduce them
Skills	• Students can use CSPs to model problems from complexity theory and decide their complexity using methods from the course.
Personal Competence	
Social Competence	
Autonomy	
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	Computer Science: Specialisation I. Computer and Software Engineering: Elective Compulsory Computer Science in Engineering: Specialisation I. Computer Science: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory

Course L3002: Constraint Satisfaction Problems

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Antoine Mottet
Language	EN
Cycle	SoSe
Content	This course gives an introduction to the topic of constraint satisfaction problems and their complexity. A constraint satisfaction problem (CSP) is a computational problem of the form "Given variables and constraints on the variables, does there exist an assignment of the variables to some concrete domain that satisfies all the constraints?" The framework of CSPs is very general, and in fact every computational problem is equivalent to a CSP. The study of CSPs has been very prolific in the past, both in practice (e.g., with SAT solvers) and in complexity theory, a prominent field of theoretical computer science. In this course, we will review the theoretical aspects of CSPs. The course will cover the basics of the theory such as the universal-algebraic approach to constraint satisfaction and several classical algorithms such as local consistency checking and the Bulatov-Dalmau algorithm. Basic knowledge in predicate logic and an affinity to abstract mathematical thinking are highly recommended in order to follow this course.
Literature	

Course L3003: Constraint Satisfaction Problems

Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Antoine Mottet
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1908: Fundamentals of Operating Systems

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Fundamentals of Operating Systems (L3148)	Lecture	2	3
Fundamentals of Operating Systems (L3149)	Recitation Section (small)	2	3

Module Responsible	Prof. Christian Dietrich
Admission Requirements	None
Recommended Previous Knowledge	• Procedural programming in C, as well as associated tools (editor, linker, compiler) • Foundations of computer architecture
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The course provides basic knowledge about the structure, functionality and system-level use of operating systems. Using the model of a multi-level machine, students learn about operating system abstractions such as processes, threads, virtual memory, files, device files and inter-process communication, as well as techniques for their efficient implementation. This includes strategies for process scheduling, latency minimization through buffering, and main and background memory management. Furthermore, they know the topics of security in the operating system context and aspects of system-oriented software development in C. In the lecture-accompanying exercises, they deepened material practically on the basis programming tasks in C from the range of the UNIX system programming. The students are familiar with the operating system functions for single-processor systems. They have become familiar with special issues relating to multiprocessor systems (based on shared memory) in passing and in relation to functions for coordinating concurrent programs. Similarly, they know the topic of real-time processing to some extent only in relation to process scheduling.
Skills	Students will be able to use the POSIX system interface to access the various resources of the computing system. They are able to grasp technical documentation in order to implement complex interaction protocols. They are able to recognize concurrency problems and avoid them with blocking synchronization primitives.
Personal Competence	
Social Competence	Students are able to discuss and collaboratively present a problem in small groups with reference to operating systems and systems software.
Autonomy	Students are able to independently prepare and review the lecture content.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Elective Compulsory Computer Science: Specialisation I. Computer and Software Engineering: Elective Compulsory Computer Science in Engineering: Specialisation I. Computer Science: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory

Course L3148: Fundamentals of Operating Systems	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Dietrich
Language	DE/EN
Cycle	SoSe
Content	• Basic OS concepts • System-oriented software development in C • Files and file systems • Processes and threads • Interrupts, system calls and signals • Process scheduling • Memory based interaction • Resource management, synchronization and jamming • Inter-process communication • Memory organization • Storage virtualization • System security and access protection
Literature	• Operating Systems. Internals and Design Principles; William Stallings; Prentice Hall 2008; ISBN: 978-0136006329. • Operating System Concepts; Abraham Silberschatz, Greg Gagne, Peter Bear Galvin; John Wiley & Sons, Inc.; 2005 ISBN: 0-471-69466-5. • Modern Operating Systems; Andrew S. Tanenbaum; Prentice Hall 2007 ISBN: 978-0136006633 • Structured Computer Organization; Andrew S. Tanenbaum; Prentice Hall 2006 ISBN: 978-0131485211.

Course L3149: Fundamentals of Operating Systems	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Dietrich
Language	DE/EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Specialization III. Engineering Science

Module M0536: Fundamentals of Fluid Mechanics

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Fundamentals of Fluid Mechanics (L0091)	Lecture	2	2
Fundamentals on Fluid Mechanics (L2933)	Recitation Section (small)	2	2
Fluid Mechanics for Process Engineering (L0092)	Recitation Section (large)	2	2

Module Responsible	Prof. Michael Schlüter
Admission Requirements	None
Recommended Previous Knowledge	• Mathematics I+II+III • Technical Mechanics I+II • Technical Thermodynamics I+II • Working with force balances • Simplification and solving of partial differential equations • Integration
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to: • explain the difference between different types of flow • give an overview for different applications of the Reynolds Transport-Theorem in process engineering • explain simplifications of the Continuity- and Navier-Stokes-Equation by using physical boundary conditions
Skills	The students are able to • describe and model incompressible flows mathematically • reduce the governing equations of fluid mechanics by simplifications to archive quantitative solutions e.g. by integration • notice the dependency between theory and technical applications • use the learned basics for fluid dynamical applications in fields of process engineering
Personal Competence	
Social Competence	The students • are capable to gather information from subject related, professional publications and relate that information to the context of the lecture and • able to work together on subject related tasks in small groups. They are able to present their results effectively in English (e.g. during small group exercises) • are able to work out solutions for exercises by themselves, to discuss the solutions orally and to present the results.
Autonomy	The students are able to • search further literature for each topic and to expand their knowledge with this literature, • work on their exercises by their own and to evaluate their actual knowledge with the feedback.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** No / 5 % / Midterm
Examination	Written exam
Examination duration and scale	3 hours
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess 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 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 L0091: Fundamentals of Fluid Mechanics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	SoSe
Content	• fluid properties • hydrostatic • overall balances - theory of streamline • overall balances- conservation equations • differential balances - Navier Stokes equations • irrotational flows - Potenzialströmungen • flow around bodies - theory of physical similarity • turbulent flows • compressible flows
Literature	1. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. 2. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. 3. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994 4. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006 5. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008 6. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007 7. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2009 8. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007 9. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008 10. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006 11. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882. 12. White, F.: Fluid Mechanics, Mcgraw-Hill, ISBN-10: 0071311211, ISBN-13: 978-0071311212, 2011

Course L2933: Fundamentals on Fluid Mechanics	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	SoSe
Content	In the group exercise, the contents of the lecture are taken up and deepened by means of exercises. The exercise tasks correspond in quality and scope to the tasks of the written exam. Topics: Reynolds transport-theorem, pipe flow, free jet, angular momentum, Navier-Stokes equations, potential theory, mock exam, pipe hydraulics, pump design.
Literature	Heinz Herwig: Strömungsmechanik, Eine Einführung in die Physik und die mathematische Modellierung von Strömungen, Springer Verlag, Berlin, 978-3-540-32441-6 (ISBN) Herbert Oertel, Martin Böhle, Thomas Reviol: Strömungsmechanik für Ingenieure und Naturwissenschaftler, Springer Verlag, Berlin, ISBN: 978-3-658-07786-0 Joseph Spurk, Nuri Aksel: Strömungslehre, Einführung in die Theorie der Strömungen, Springer Verlag, Berlin, ISBN: 978-3-642-13143-1.

Course L0092: Fluid Mechanics for Process Engineering	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Schlüter
Language	DE
Cycle	SoSe
Content	In the exercise-lecture the topics from the main lecture are discussed intensively and transferred into application. For that, the students receive example tasks for download. The students solve these problems based on the lecture material either independently or in small groups. The solution is discussed with the students under scientific supervision and parts of the solutions are presented on the chalk board. At the end of each exercise-lecture, the correct solution is presented on the chalk board. Parallel to the exercise-lecture tutorials are held where the student solve exam questions under a set time-frame in small groups and discuss the solutions afterwards.
Literature	1. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009. 2. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006. 3. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994 4. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006 5. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008 6. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007 7. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2009 8. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007 9. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008 10. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006 11. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882. 12. White, F.: Fluid Mechanics, Mcgraw-Hill, ISBN-10: 0071311211, ISBN-13: 978-0071311212, 2011

Module M0634: Introduction into Medical Technology and Systems

Courses

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

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

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

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

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

Module 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 M0757: Biochemistry and Microbiology

Courses

Title	Typ	Hrs/wk	CP
Biochemistry (L0351)	Lecture	2	2
Biochemistry (L0728)	Project-/problem-based Learning	1	1
Microbiology (L0881)	Lecture	2	2
Microbiology (L0888)	Project-/problem-based Learning	1	1

Module Responsible	Prof. Johannes Gescher
Admission Requirements	None
Recommended Previous Knowledge	none
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	At the end of this module the students can: - explain the methods of biological and biochemical research to determine the properties of biomolecules - name the basic components of a living organism - explain the principles of metabolism - describe the structure of living cells -
Skills	
Personal Competence	
Social Competence	The students are able, - to gather knowledge in groups of about 10 students - to introduce their own knowledge and to argue their view in discussions in teams - to divide a complex task into subtasks, solve these and to present the combined results
Autonomy	The students are able to present the results of their subtasks in a written report
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	Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective Compulsory Orientation Studies: Core Qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0351: Biochemistry	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Paul Bubenheim
Language	DE
Cycle	SoSe

Content	1. The molecular logic of Life
	2. Biomolecules:
	    1. Amino acids, peptides, proteins
	    2. Carbohydrates
	    3. Lipids
	3. Protein functions, Enzymes:
	    1. Michaelis-Menten kinetics
	    2. Enzyme regulation
	    3. Enzyme nomenclature
	4. Cofactors and cosubstrates, vitamines
	5. Metabolism:
	    1. Basic principles
	    2. Photosynthesis
	    3. Glycolysis
	    4. Citric acid cycle
	    5. Respiration
	    6. Anaerobic respirations
	    7. Fatty acid metabolism
	    8. Amino acid metabolism

Literature	Biochemie, H. Robert Horton, Laurence A. Moran, K. Gray Scrimeour, Marc D. Perry, J. David Rawn, Pearson Studium, München Prinzipien der Biochemie, A. L. Lehninger, de Gruyter Verlag Berlin

Course L0728: Biochemistry	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Dr. Paul Bubenheim
Language	DE
Cycle	SoSe

Content	1. The molecular logic of Life
	2. Biomolecules:
	    1. Amino acids, peptides, proteins
	    2. Carbohydrates
	    3. Lipids
	3. Protein functions, Enzymes:
	    1. Michaelis-Menten kinetics
	    2. Enzyme regulation
	    3. Enzyme nomenclature
	4. Cofactors and cosubstrates, vitamines
	5. Metabolism:
	    1. Basic principles
	    2. Photosynthesis
	    3. Glycolysis
	    4. Citric acid cycle
	    5. Respiration
	    6. Anaerobic respirations
	    7. Fatty acid metabolism
	    8. Amino acid metabolism

Literature	Biochemie, H. Robert Horton, Laurence A. Moran, K. Gray Scrimeour, Marc D. Perry, J. David Rawn, Pearson Studium, München Prinzipien der Biochemie, A. L. Lehninger, de Gruyter Verlag Berlin

<table>
<tr><th colspan="2">Course L0881: Microbiology</th></tr>
<tr><td>Typ</td><td>Lecture</td></tr>
<tr><td>Hrs/wk</td><td>2</td></tr>
<tr><td>CP</td><td>2</td></tr>
<tr><td>Workload in Hours</td><td>Independent Study Time 32, Study Time in Lecture 28</td></tr>
<tr><td>Lecturer</td><td>Prof. Johannes Gescher</td></tr>
<tr><td>Language</td><td>DE</td></tr>
<tr><td>Cycle</td><td>SoSe</td></tr>
<tr><td>Content</td><td>1. The procaryotic cell
evolution
taxonomy and specific properties of Archaea, Bacteria, and viruses
structure and properties of the cell
growth
2. Metabolism
fermentation and anaerobic respiration
methanogenesis and the anaerobic food chain
degradation of polymers
chemolithotrophy
3. Microorganisms in relation to the environment
chemotaxis and motility
Elemental cycle of carbon, nitrogen and sulfur
biofilms
symbiotic relationships
extremophiles
biotechnology</td></tr>
<tr><td>Literature</td><td>• Allgemeine Mikrobiologie, 8. Aufl., 2007, Fuchs, G. (Hrsg.), Thieme Verlag (54,95 €)

• Mikrobiologie, 13 Aufl., 2013, Madigan, M., Martinko, J. M., Stahl, D. A., Clark, D. P. (Hrsg.), ehemals „Brock“, Pearson Verlag (89,95 €)

• Taschenlehrbuch Biologie Mikrobiologie, 2008, Munk, K. (Hrsg.), Thieme Verlag

• Grundlagen der Mikrobiologie, 4. Aufl., 2010, Cypionka, H., Springer Verlag (29,95 €), http://www.grundlagen-der-mikrobiologie.icbm.de/</td></tr>
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Course L0888: Microbiology	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Johannes Gescher
Language	DE
Cycle	SoSe
Content	1. The procaryotic cell • evolution • taxonomy and specific properties of Archaea, Bacteria, and viruses • structure and properties of the cell • growth 2. Metabolism • fermentation and anaerobic respiration • methanogenesis and the anaerobic food chain • degradation of polymers • chemolithotrophy 3. Microorganisms in relation to the environment • chemotaxis and motility • Elemental cycle of carbon, nitrogen and sulfur • biofilms • symbiotic relationships • extremophiles • biotechnology
Literature	• **Allgemeine Mikrobiologie**, 8. Aufl., 2007, Fuchs, G. (Hrsg.), Thieme Verlag (54,95 €) • **Mikrobiologie**, 13 Aufl., 2013, Madigan, M., Martinko, J. M., Stahl, D. A., Clark, D. P. (Hrsg.), ehemals „Brock“, Pearson Verlag (89,95 €) • Taschenlehrbuch Biologie **Mikrobiologie**, 2008, Munk, K. (Hrsg.), Thieme Verlag • **Grundlagen der Mikrobiologie**, 4. Aufl., 2010, Cypionka, H., Springer Verlag (29,95 €), http://www.grundlagen-der-mikrobiologie.icbm.de/

Module M0938: Bioprocess Engineering - Fundamentals

Courses

Title	Typ	Hrs/wk	CP
Bioprocess Engineering - Fundamentals (L0841)	Lecture	2	3
Bioprocess Engineering- Fundamentals (L0842)	Recitation Section (large)	2	1
Bioprocess Engineering - Fundamental Practical Course (L0843)	Practical Course	2	2

Module Responsible	Prof. Andreas Liese
Admission Requirements	None
Recommended Previous Knowledge	module "organic chemistry", module "fundamentals for process engineering"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to describe the basic concepts of bioprocess engineering. They are able to classify different types of kinetics for enzymes and microorganisms, as well as to differentiate different types of inhibition. The parameters of stoichiometry and rheology can be named and mass transport processes in bioreactors can be explained. The students are capable to explain fundamental bioprocess management, sterilization technology and downstream processing in detail.
Skills	After successful completion of this module, students should be able to • describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters • predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on the fermentation process • analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations • distinguish between scale-up criteria for different bioreactors and bioprocesses (anaerobic, aerobic as well as microaerobic) to compare them as well as to apply them to current biotechnical problem • propose solutions to complicated biotechnological problems and to deduce the corresponding models • to explore new knowledge resources and to apply the newly gained contents • identify scientific problems with concrete industrial use and to formulate solutions. • to document and discuss their procedures as well as results in a scientific manner
Personal Competence	
Social Competence	After completion of this module participants should be able to debate technical questions in small teams to enhance the ability to take position to their own opinions and increase their capacity for teamwork in engineering and scientific environments.
Autonomy	After completion of this module participants will be able to solve a technical problem in a team independently by organizing their workflow and to present their results in a plenum.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** Yes / 5 % / Subject theoretical and practical work /
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core Qualification: Compulsory

Course L0841: Bioprocess Engineering - Fundamentals	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
Language	DE
Cycle	SoSe
Content	• Introduction: state-of-the-art and development trends in the biotechnology, introduction to the lecture • Enzyme kinetics: Michaelis-Menten, differnt types of enzyme inhibition, linearization, conversion, yield, selectivity (Prof. Liese) • Stoichiometry: coefficient of respiration, electron balance, degree of reduction, coefficient of yield, theoretical oxygen demand (Prof. Liese) • Microbial growth kinetic: batch- and chemostat culture (Prof. Zeng) • Kinetic of subtrate consumption and product formation (Prof. Zeng) • Rheology: non-newtonian fluids, viscosity, agitators, energy input (Prof. Liese) • Transport process in a bioreactor (Prof. Zeng) • Technology of sterilization (Prof. Zeng) • Fundamentals of bioprocess management: bioreactors and calculation of batch, fed-batch and continuouse bioprocesses (Prof. Zeng/Prof. Liese) • Downstream technology in biotechnology: cell breakdown, zentrifugation, filtration, aqueous two phase systems (Prof. Liese)
Literature	K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012 H. Chmiel: Bioprozeßtechnik, Elsevier, 2006 R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010 H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997 P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013

Course L0842: Bioprocess Engineering- Fundamentals	
Typ	Recitation Section (large)
Hrs/wk	2
CP	1
Workload in Hours	Independent Study Time 2, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
Language	DE
Cycle	SoSe
Content	1. Introduction (Prof. Liese, Prof. Zeng) 2. Enzymatic kinetics (Prof. Liese) 3. Stoichiometry I + II (Prof. Liese) 4. Microbial Kinetics I+II (Prof. Zeng) 5. Rheology (Prof. Liese) 6. Mass transfer in bioprocess (Prof. Zeng) 7. Continuous culture (Chemostat) (Prof. Zeng) 8. Sterilisation (Prof. Zeng) 9. Downstream processing (Prof. Liese) 10. Repetition (Reserve) (Prof. Liese, Prof. Zeng)
Literature	siehe Vorlesung

Course L0843: Bioprocess Engineering - Fundamental Practical Course	
Typ	Practical Course
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Andreas Liese
Language	DE
Cycle	SoSe
Content	In this course fermentation and downstream technologies on the example of the production of an enzyme by means of a recombinant microorganism is learned. Detailed characterization and simulation of enzyme kinetics as well as application of the enzyme in a bioreactor is carried out. The students document their experiments and results in a protocol.
Literature	Skript

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 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	Prof. Tobias Lange, 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, 17. Auflage, Thieme Verlag Stuttgart, 2016

Module M0706: Geotechnics I

Courses

Title	Typ	Hrs/wk	CP
Soil Mechanics (L0550)	Lecture	2	2
Soil Mechanics (L0551)	Recitation Section (large)	2	2
Soil Mechanics (L1493)	Recitation Section (small)	2	2

Module Responsible	Prof. Jürgen Grabe
Admission Requirements	None
Recommended Previous Knowledge	Modules : • Mechanics I-II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students know the basics of soil mechanics as the structure and characteristics of soil, stress distribution due to weight, water or structures, consolidation and settlement calculations, as well as failure of the soil due to ground- or slope failure.
Skills	After the successful completion of the module the students should be able to describe the mechanical properties and to evaluate them with the help of geotechnical standard tests. They can calculate stresses and deformation in the soils due to weight or influence of structures. They are are able to prove the usability (settlements) for shallow foundations.
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	**Compulsory** No · **Bonus** 20 % · **Form** Attestation · **Description**
Examination	Written exam
Examination duration and scale	90 minutes
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Civil Engineering: Compulsory Civil- and Environmental Engineering: Core Qualification: Compulsory Logistics and Mobility: Specialisation Traffic Planning and 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

Course L0550: Soil Mechanics

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe/SoSe
Content	• Structure of the soil • Ground surveying • Compsitition and properties of the soil • Groundwater • One-dimensional compression • Spreading of stresses • Settlement calculation • Consolidation • Shear strength • Earth pressure • Slope failure • Ground failure • Suspension based earth tenches
Literature	• Vorlesungsumdruck, s. ww.tu-harburg.de/gbt • Grabe, J. (2004): Bodenmechanik und Grundbau • Gudehus, G. (1981): Bodenmechanik • Kolymbas, D. (1998): Geotechnik - Bodenmechanik und Grundbau • Grundbau-Taschenbuch, Teil 1, aktuelle Auflage

Course L0551: Soil Mechanics	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe/SoSe
Content	See interlocking course
Literature	See interlocking course

Course L1493: Soil Mechanics	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Jürgen Grabe
Language	DE
Cycle	WiSe/SoSe
Content	See interlocking course
Literature	See interlocking course

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 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 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 arbitrary 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 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 Electrical Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical 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 Logistics and Mobility: Specialisation 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: Core Qualification: 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 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 M0567: Theoretical Electrical Engineering I: Time-Independent Fields

Courses

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

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

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

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

Module 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 M0672: Signals and Systems

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

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

Course L0432: Signals and Systems

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

Content

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

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

Literature

- T. Frey , M. Bossert , Signal- und Systemtheorie, B.G. Teubner Verlag 2004
- K. Kammeyer, K. Kroschel, Digitale Signalverarbeitung, Teubner Verlag.
- B. Girod ,R. Rabensteiner , A. Stenger , Einführung in die Systemtheorie, B.G. Teubner, Stuttgart, 1997
- J.R. Ohm, H.D. Lüke , Signalübertragung, Springer-Verlag 8. Auflage, 2002
- S. Haykin, B. van Veen: Signals and systems. Wiley.
- Oppenheim, A.S. Willsky: Signals and Systems. Pearson.

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

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

Module M0580: Principles of Building Materials and Building Physics

Courses			
Title	**Typ**	**Hrs/wk**	**CP**
Building Physics (L0217)	Lecture	2	2
Building Physics (L0219)	Recitation Section (large)	1	1
Building Physics (L0247)	Recitation Section (small)	1	1
Principles of Building Materials (L0215)	Lecture	2	2

Module Responsible	Prof. Frank Schmidt-Döhl
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of physics, chemistry and mathematics from school
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to identify fundamental effects of action to materials and structures, to explain different types of mechanical behaviour, to describe the structure of building materials and the correlations between structure and other properties, to show methods of joining and of corrosion processes and to describe the most important regularities and properties of building materials and structures and their measurement in the field of protection against moisture, coldness, fire and noise.
Skills	The students are able to work with the most important standardized methods and regularities in the field of moisture protection, the German regulation for energy saving, fire protection and noise protection in the case of a small building.
Personal Competence	
Social Competence	The students are able to support each other to learn the very extensive specialist knowledge.
Autonomy	The students are able to make the timing and the operation steps to learn the specialist knowledge of a very extensive field.
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	2 h written exam
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Civil Engineering: Compulsory Civil- and Environmental Engineering: Core Qualification: Compulsory Integrated Building Technology: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0217: Building Physics

Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	WiSe
Content	Heat transport, thermal bridges, balances of energy consumption, German regulation for energy saving, heat protection in summer, moisture transport, condensation moisture, protection against mold, fire protection, noise protection
Literature	Fischer, H.-M. ; Freymuth, H.; Häupl, P.; Homann, M.; Jenisch, R.; Richter, E.; Stohrer, M.: Lehrbuch der Bauphysik. Vieweg und Teubner Verlag, Wiesbaden, ISBN 978-3-519-55014-3

Course L0219: Building Physics

Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0247: Building Physics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L0215: Principles of Building Materials	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Frank Schmidt-Döhl
Language	DE
Cycle	WiSe
Content	Structure of building materials Effects of action Fundamentals of mechanical behaviour Material testing Principles of metals Joining methods
Literature	Wendehorst, R.: Baustoffkunde. ISBN 3-8351-0132-3 Scholz, W.:Baustoffkenntnis. ISBN 3-8041-4197-8

Module M0687: Chemistry

Courses

Title	Typ	Hrs/wk	CP
Chemistry I+II (L0460)	Lecture	4	4
Chemistry I+II (L0475)	Recitation Section (large)	2	2

Module Responsible	Dr. Dorothea Rechtenbach
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 are able to name and to describe basic principles and applications of general chemistry (structure of matter, periodic table, chemical bonds), physical chemistry (aggregate states, separating processes, thermodynamics, kinetics), inorganic chemistry (acid/base, pH-value, salts, solubility, redox, metals) and organic chemistry (aliphatic hydrocarbons, functional groups, carbonyl compounds, aromates, reaction mechanisms, natural products, synthetic polymers). Furthermore students are able to explain basic chemical terms.
Skills	After successful completion of this module students are able to describe substance groups and chemical compounds. On this basis, they are capable of explaining, choosing and applying specific methods and various reaction mechanisms.
Personal Competence	
Social Competence	Students are able to take part in discussions on chemical issues and problems as a member of an interdisciplinary team. They can contribute to those discussion by their own statements.
Autonomy	After successful completion of this module students are able to solve chemical problems independently by defending proposed approaches with arguments. They can also document their approaches.
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): Core Qualification: Compulsory Civil- and Environmental Engineering: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L0460: Chemistry I+II	
Typ	Lecture
Hrs/wk	4
CP	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Dr. Christoph Wutz
Language	DE
Cycle	WiSe
Content	Chemistry I: - Structure of matter - Periodic table - Electronegativity - Chemical bonds - Solid compounds and solutions - Chemistry of water - Chemical reactions and equilibria - Acid-base reactions - Redox reactions Chemistry II: - Simple compounds of carbon, aliphatic hydrocarbons, aromatic hydrocarbons, - Alkohols, phenols, ether, aldehydes, ketones, carbonic acids, ester, amines, amino acids, fats, sugars - Reaction mechanisms, radical reactions, nucleophilic substitution, elimination reactions, addition reaction - Practical apllications and examples
Literature	- Blumenthal, Linke, Vieth: Chemie - Grundwissen für Ingenieure - Kickelbick: Chemie für Ingenieure (Pearson) - Mortimer: Chemie. Basiswissen der Chemie. - Brown, LeMay, Bursten: Chemie. Studieren kompakt. - Schmuck: Basisbuch Organische Chemie (Pearson)

Course L0475: Chemistry I+II	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Dorothea Rechtenbach
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0740: Structural Analysis I

Courses

Title	Typ	Hrs/wk	CP
Structural Analysis I (L0666)	Lecture	2	3
Structural Analysis I (L0667)	Recitation Section (large)	2	2
Structural Analysis I (L3133)	Recitation Section (small)	1	1

Module Responsible	Prof. Bastian Oesterle
Admission Requirements	None
Recommended Previous Knowledge	Mechanics I, Mathematics I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successfully completing this module, students can express the basic aspects of linear frame analysis of statically determinate and indeterminate systems.
Skills	After successful completion of this module, the students are able to distinguish between statically determinate and indeterminate structures. They are able to analyze state variables and to construct influence lines of statically determinate plane and spatial frame and truss structures.
Personal Competence	
Social Competence	Students can • participate in subject-specific and interdisciplinary discussions, • defend their own work results in front of others • promote the scientific development of colleagues • Furthermore, they can give and accept professional constructive criticism
Autonomy	The students are able work in-term homework assignments. Due to the in-term feedback, they are enabled to self-assess their learning progress during the lecture period, already.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** No · **Bonus** 10 % · **Form** Written elaboration · **Description** Hausübungen mit Testat, betreut durch Studentische Tutoren (Tutorium)
Examination	Written exam
Examination duration and scale	90 minutes
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Civil Engineering: Compulsory Civil- and Environmental Engineering: Core Qualification: Compulsory Logistics and Mobility: Specialisation Traffic Planning and 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

Course L0666: Structural Analysis I

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	WiSe
Content	• modeling of structures • theory of plane and spacial structures • assessment of structural behaviour, degree of static indeterminacy and kinematics • analysis of forces and moments, as well as diplscements and rotations • principle of virtual work • influence lines • Force Method for statically indeterminate structures
Literature	• Vorlesungsmanuskript • Bletzinger et al.: Aufgabensammlung zur Baustatik: Übungsaufgaben zur Berechnung ebener Stabtragwerke. Hanser. • Dinkler: Grundlagen der Baustatik. Springer. • Marti: Baustatik. Ernst und Sohn.

Course L0667: Structural Analysis I	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Bastian Oesterle
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L3133: Structural Analysis I	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Bastian Oesterle
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 Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: 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	WiSe
Content	Chemische Bindungen und Aufbau von Festkörpern; Kristallaufbau; Werkstoffprüfung; Schweißbarkeit; Herstellung von Keramiken; Aufbau und Eigenschaften der Keramik; Herstellung, Aufbau und Eigenschaften von Gläsern; Polymerwerkstoffe, Makromolekularer Aufbau; Struktur und Eigenschaften der Polymere; Polymerverarbeitung; Verbundwerkstoffe
Literature	Vorlesungsskript 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 M0808: Finite Elements Methods

Courses

Title	Typ	Hrs/wk	CP
Finite Element Methods (L0291)	Lecture	2	3
Finite Element Methods (L0804)	Recitation Section (large)	2	3

Module Responsible	Prof. Benedikt Kriegesmann
Admission Requirements	None
Recommended Previous Knowledge	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students possess an in-depth knowledge regarding the derivation of the finite element method and are able to give an overview of the theoretical and methodical basis of the method.
Skills	The students are capable to handle engineering problems by formulating suitable finite elements, assembling the corresponding system matrices, and solving the resulting system of equations.
Personal Competence	
Social Competence	Students can work in small groups on specific problems to arrive at joint solutions.
Autonomy	The students are able to independently solve challenging computational problems and develop own finite element routines. Problems can be identified and the results are critically scrutinized.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** No, **Bonus** 20 %, **Form** Midterm, **Description**
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Aeronautics: Core Qualification: Elective Compulsory Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory Product Development, Materials and Production: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory

Course L0291: Finite Element Methods	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Benedikt Kriegesmann
Language	EN
Cycle	WiSe
Content	- General overview on modern engineering - Displacement method - Hybrid formulation - Isoparametric elements - Numerical integration - Solving systems of equations (statics, dynamics) - Eigenvalue problems - Non-linear systems - Applications - Programming of elements (Matlab, hands-on sessions) - Applications
Literature	Bathe, K.-J. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin

Course L0804: Finite Element Methods	
Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Benedikt Kriegesmann
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0945: Bioprocess Engineering - Advanced

Courses

Title	Typ	Hrs/wk	CP
Bioprocess Engineering - Advanced (L1107)	Lecture	2	4
Bioprocess Engineering - Advanced (L1108)	Recitation Section (small)	2	2

Module Responsible	Prof. Ralf Pörtner
Admission Requirements	None
Recommended Previous Knowledge	Content of module "Biochemisty and Microbiology" Content of module "Biochemical Engineering I"
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	After successful completion of this module, students should be able - explain the microbial, energetic and engineering principles of fermentation process, - explain different kinetic approaches for cell growth, substrate uptake and product formation and apply them for process development, - understand and quantify transport phenomena in bioreactor and consider them for bioprocess scale-up - identify specific scientific problems and solutions for different types of fermentation processes
Skills	After successful completion of this module, students should be able to - to identify scientific questions or possible practical problems for concrete industrial applications (eg cultivation of microorganisms and animal cells) and to formulate solutions , - to assess the application of scale-up criteria for different types of bioreactors and processes and to apply these criteria to given problems (anaerobic , aerobic or microaerobic bioprocesses), - to formulate questions for the analysis and optimization of real biotechnological production processes appropriate solutions, - to describe the effects of the energy generation, the regeneration of reduction equivalents , and the growth inhibition of the behavior of microorganisms and to the total fermentation process qualitatively, - to establish material balance and fermentation equations and solve them to determine the kinetic parameters of different approaches, - to select process control strategies (batch , fed-batch ,or continuous culture) appropriately and to calculate basic types and evaluate them.
Personal Competence	
Social Competence	After completion of this module participants should be able to debate technical questions in small teams to enhance the ability to take position to their own opinions and increase their capacity for teamwork.
Autonomy	After completion of this module participants are able to acquire new sources of knowledge and apply their knowledge to previously unknown issues and to present these.
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	Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Biotechnologies: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory

Course L1107: Bioprocess Engineering - Advanced	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Prof. Andreas Liese
Language	DE
Cycle	WiSe
Content	• Introduction: state-of-the-art and development trends of microbial and biocatalytic bioprocesses, introduction to the lecture • Microbial principles of fermentation, Energetic fundamentals of bioreaction • Medium design and optimization, sterilization • Kinetics of cell growth • Kinetics of substrate consumption and product formation • Material balances and metabolic flux analysis • Transport phenomena in bioreactor and bioprocess scale-u • Anaerobic fermentation process, integrated downstream processin • Microaerobic bioprocess: optimal O2 supply, process control and scale-u • Aerobic process and high cell density culture • Problem-based learning with selected bioprocesses
Literature	P. F. Stanbury, A. Whitaker, S. J. Hall, Principles of Fermentation Technology, 3 rd. Edition, Butterworth-Heinemann, 2016. H. Chmiel: Bioprozeßtechnik, Elsevier, 2006 R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010 H.W. Blanch, D. Clark: Biochemical Engineering, Taylor & Francis, 1997 P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013 Skripte für die Vorlesung

Course L1108: Bioprocess Engineering - Advanced	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Ralf Pörtner, Prof. Andreas Liese
Language	DE
Cycle	WiSe
Content	• Introduction: state-of-the-art and development trends of microbial and biocatalytic bioprocesses, introduction to the lecture • Microbial principles of fermentation, Energetic fundamentals of bioreaction • Medium design and optimization, sterilization • Kinetics of cell growth • Kinetics of substrate consumption and product formation • Material balances and metabolic flux analysis • Transport phenomena in bioreactor and bioprocess scale-u • Anaerobic fermentation process, integrated downstream processin • Microaerobic bioprocess: optimal O2 supply, process control and scale-u • Aerobic process and high cell density culture • Problem-based learning with selected bioprocesses The students present exercises and discuss them with their fellow students and faculty statt. In the PBL part of the class the students discuss scientific questions in teams. They acquire knowledge and apply it to unknown questions, present their results and argue their opinions.
Literature	P. F. Stanbury, A. Whitaker, S. J. Hall, Principles of Fermentation Technology, 3 rd. Edition, Butterworth-Heinemann, 2016. H. Chmiel: Bioprozeßtechnik, Elsevier, 2006 R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010 P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013 Skripte für die Vorlesung

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 M0783: Measurements: Methods and Data Processing

Courses

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

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

Course L0781: EE Experimental Lab

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

Course L0779: Measurements: Methods and Data Processing

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

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

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

Courses

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

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

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

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

Module M0538: Heat and Mass Transfer

Courses

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

Module Responsible	Prof. Irina Smirnova
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge: Technical Thermodynamics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• The students are capable of explaining qualitative and determining quantitative heat transfer in procedural apparatus (e. g. heat exchanger, chemical reactors). • They are capable of distinguish and characterize different kinds of heat transfer mechanisms namely heat conduction, heat transfer and thermal radiation. • The students have the ability to explain the physical basis for mass transfer in detail and to describe mass transfer qualitative and quantitative by using suitable mass transfer theories. • They are able to depict the analogy between heat- and mass transfer and to describe complex linked processes in detail.
Skills	• The students are able to set reasonable system boundaries for a given transport problem by using the gained knowledge and to balance the corresponding energy and mass flow, respectively. • They are capable to solve specific heat transfer problems (e.g. heated chemical reactors, temperature alteration in fluids) and to calculate the corresponding heat flows. • Using dimensionless quantities, the students can execute scaling up of technical processes or apparatus. • They are able to distinguish between diffusion, convective mass transition and mass transfer. They can use this knowledge for the description and design of apparatus (e.g. extraction column, rectification column). • In this context, the students are capable to choose and design fundamental types of heat and mass exchanger for a specific application considering their advantages and disadvantages, respectively. • In addition, they can calculate both, steady-state and non-steady-state processes in procedural apparatus. • The students are capable to connect their knowledge obtained in this course with knowlegde of other courses (In particular the courses thermodynamics, fluid mechanics and chemical process engineering) to solve concrete technical problems.
Personal Competence	
Social Competence	• The students are capable to work on subject-specific challenges in teams and to present the results orally in a reasonable manner to tutors and other students.
Autonomy	• The students are able to find and evaluate necessary information from suitable sources • They are able to prove their level of knowledge during the course with accompanying procedure continuously (clicker-system, exam-like assignments) and on this basis they can control their learning processes.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 minutes; theoretical questions and calculations
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory General Engineering Science (German program, 7 semester): Specialisation Chemical and Bioengineering: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Chemical and Bioprocess Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core Qualification: Compulsory

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

Course L0102: Heat and Mass Transfer	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Irina Smirnova
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

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

Module 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 M0675: Introduction to Communications and Random Processes

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

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

Course L0442: Introduction to Communications and Random Processes

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

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

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

	- SNR gain of DPCM over PCM
	- Delta modulation
	• Fundamentals of information theory and coding
	  ◦ Definitions of information: Self-information, entropy
	  ◦ Binary entropy function
	  ◦ Source coding theorem
	  ◦ Source coding: Huffman code
	  ◦ Mutual information and channel capacity
	  ◦ Channel capacity of the AWGN channel and the binary input AWGN channel
	  ◦ Channel coding theorem
	  ◦ Principles of channel coding: Code rate and data rate, Hamming distance, minimum Hamming distance, error detection and error correction
	  ◦ Examples for channel codes: Block codes and convolutional codes, repetition code, single parity check code, Hamming code, Turbo codes
	• Combinatorics
	  ◦ Variation with and without repetition
	  ◦ Combination with and without repetition
	  ◦ Permutation, Permutation of multisets
	  ◦ Word error probabilities of linear block codes
	• Baseband transmission
	  ◦ Pulse shaping: Non-return to zero (NRZ) rectangular pulses, Manchester pulses, raised-cosine pulses, square-root raised-cosine pulses, Gaussian pulses
	  ◦ Transmit signal energy, average energy per symbol
	  ◦ Power spectral density (psd) of baseband signals
	  ◦ Definitions of signal bandwidth
	  ◦ Bandwidth efficiency
	  ◦ Intersymbol interference (ISI)
	  ◦ First and second Nyquist criterion
	  ◦ Eye patterns
	  ◦ Receive filter design: Matched filter
	  ◦ Matched-filter receiver and correlation receiver
	  ◦ Square-root Nyquist pulse shaping
	  ◦ Discrete-time AWGN channel model
	• Maximum a posteriori probability (MAP) and maximum likelihood (ML) detection
	• Bit error probability in AWGN channels for binary antipodal and on-off signaling
	• Band-pass transmission via carrier modulation
	  ◦ Amplitude modulation, frequency modulation, phase modulation
	  ◦ Linear digital modulation methods: On-off keying (OOK), phase-shift keying (PSK), amplitude shift keying (ASK), quadrature amplitude shift keying (QAM)
	•

Literature	K. Kammeyer: Nachrichtenübertragung, Teubner P.A. Höher: Grundlagen der digitalen Informationsübertragung, Teubner. M. Bossert: Einführung in die Nachrichtentechnik, Oldenbourg. J.G. Proakis, M. Salehi: Grundlagen der Kommunikationstechnik. Pearson Studium. J.G. Proakis, M. Salehi: Digital Communications. McGraw-Hill. S. Haykin: Communication Systems. Wiley J.G. Proakis, M. Salehi: Communication Systems Engineering. Prentice-Hall. J.G. Proakis, M. Salehi, G. Bauch, Contemporary Communication Systems. Cengage Learning.

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

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

Module 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** No · **Bonus** 20 % · **Form** Midterm · **Description** Midterm
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory 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 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 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 M0708: Electrical Engineering III: Circuit Theory and Transients

Courses

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

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

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

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

Module 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 M0805: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)

Courses

Title	Typ	Hrs/wk	CP
Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics) (L0516)	Lecture	2	3
Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics) (L0518)	Recitation Section (large)	2	3

Module Responsible	Prof. Benedikt Kriegesmann
Admission Requirements	None
Recommended Previous Knowledge	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students possess an in-depth knowledge in acoustics regarding acoustic waves, noise protection, and psycho acoustics and are able to give an overview of the corresponding theoretical and methodical basis.
Skills	The students are capable to handle engineering problems in acoustics by theory-based application of the demanding methodologies and measurement procedures treated within the module.
Personal Competence	
Social Competence	Students can work in small groups on specific problems to arrive at joint solutions.
Autonomy	The students are able to independently solve challenging acoustical problems in the areas treated within the module. Possible conflicting issues and limitations can be identified and the results are critically scrutinized.
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	Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Aeronautics: Core Qualification: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L0516: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr.-Ing. Sören Keuchel
Language	EN
Cycle	SoSe
Content	- Introduction and Motivation - Acoustic quantities - Acoustic waves - Sound sources, sound radiation - Sound engergy and intensity - Sound propagation - Signal processing - Psycho acoustics - Noise - Measurements in acoustics
Literature	Cremer, L.; Heckl, M. (1996): Körperschall. Springer Verlag, Berlin Veit, I. (1988): Technische Akustik. Vogel-Buchverlag, Würzburg Veit, I. (1988): Flüssigkeitsschall. Vogel-Buchverlag, Würzburg

Course L0518: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics)	
Typ	Recitation Section (large)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Dr.-Ing. Sören Keuchel
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

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 M0734: Electrical Engineering Project Laboratory

Courses

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

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

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

Module 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 Engineering Science: Specialisation Mechanical Engineering: Compulsory Engineering Science: Specialisation Biomedical Engineering: Compulsory Engineering Science: Specialisation Mechatronics: Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Maritime Technologies: 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 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

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 M0606: Numerical Algorithms in Structural Mechanics

Courses

Title	Typ	Hrs/wk	CP
Numerical Algorithms in Structural Mechanics (L0284)	Lecture	2	3
Numerical Algorithms in Structural Mechanics (L0285)	Recitation Section (small)	2	3

Module Responsible	Prof. Alexander Düster
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of partial differential equations is recommended.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to + give an overview of the standard algorithms that are used in finite element programs. + explain the structure and algorithm of finite element programs. + specify problems of numerical algorithms, to identify them in a given situation and to explain their mathematical and computer science background.
Skills	Students are able to + construct algorithms for given numerical methods. + select for a given problem of structural mechanics a suitable algorithm. + apply numerical algorithms to solve problems of structural mechanics. + implement algorithms in a high-level programming languate (here C++). + critically judge and verfiy numerical algorithms.
Personal Competence	
Social Competence	Students are able to + solve problems in heterogeneous groups. + present and discuss their results in front of others. + give and accept professional constructive criticism.
Autonomy	Students are able to + assess their knowledge by means of exercises and E-Learning. + acquaint themselves with the necessary knowledge to solve research oriented tasks. + to transform the acquired knowledge to similar problems.
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	Civil Engineering: Specialisation Computational Engineering: Elective Compulsory Materials Science: Specialisation Modeling: Elective Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory

Course L0284: Numerical Algorithms in Structural Mechanics

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Düster
Language	DE
Cycle	SoSe
Content	1. Motivation 2. Basics of C++ 3. Numerical integration 4. Solution of nonlinear problems 5. Solution of linear equation systems 6. Verification of numerical algorithms 7. Selected algorithms and data structures of a finite element code
Literature	[1] D. Yang, C++ and object-oriented numeric computing, Springer, 2001. [2] K.-J. Bathe, Finite-Elemente-Methoden, Springer, 2002.

Course L0285: Numerical Algorithms in Structural Mechanics	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Düster
Language	DE
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M0604: High-Order FEM

Courses

Title	Typ	Hrs/wk	CP
High-Order FEM (L0280)	Lecture	3	4
High-Order FEM (L0281)	Recitation Section (large)	1	2

Module Responsible	Prof. Alexander Düster
Admission Requirements	None
Recommended Previous Knowledge	Knowledge of partial differential equations is recommended.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to + give an overview of the different (h, p, hp) finite element procedures. + explain high-order finite element procedures. + specify problems of finite element procedures, to identify them in a given situation and to explain their mathematical and mechanical background.
Skills	Students are able to + apply high-order finite elements to problems of structural mechanics. + select for a given problem of structural mechanics a suitable finite element procedure. + critically judge results of high-order finite elements. + transfer their knowledge of high-order finite elements to new problems.
Personal Competence	
Social Competence	Students are able to + solve problems in heterogeneous groups. + present and discuss their results in front of others. + give and accept professional constructive criticism.
Autonomy	Students are able to + assess their knowledge by means of exercises and E-Learning. + acquaint themselves with the necessary knowledge to solve research oriented tasks. + to transform the acquired knowledge to similar problems.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** No / 10 % / Presentation / Forschendes Lernen
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Civil Engineering: Specialisation Computational Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory

Course L0280: High-Order FEM	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Alexander Düster
Language	EN
Cycle	SoSe
Content	1. Introduction 2. Motivation 3. Hierarchic shape functions 4. Mapping functions 5. Computation of element matrices, assembly, constraint enforcement and solution 6. Convergence characteristics 7. Mechanical models and finite elements for thin-walled structures 8. Computation of thin-walled structures 9. Error estimation and hp-adaptivity 10. High-order fictitious domain methods
Literature	[1] Alexander Düster, High-Order FEM, Lecture Notes, Technische Universität Hamburg-Harburg, 164 pages, 2014 [2] Barna Szabo, Ivo Babuska, Introduction to Finite Element Analysis – Formulation, Verification and Validation, John Wiley & Sons, 2011

Course L0281: High-Order FEM	
Typ	Recitation Section (large)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Alexander Düster
Language	EN
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 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 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 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 IV. Subject Specific Focus

Module M1321: Technical Complementary Course I for Technomathematics (according to Subject Specific Regulations)

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

Module Responsible	Prof. Anusch Taraz
Admission Requirements	None
Recommended Previous Knowledge	see selected module according to FSPO
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	see selected module according to FSPO
Skills	see selected module according to FSPO
Personal Competence	
Social Competence	see selected module according to FSPO
Autonomy	see selected module according to FSPO
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Technomathematics: Specialisation IV. Subject Specific Focus: Elective Compulsory

Module M1322: Technical Complementary Course II for Technomathematics (according to Subject Specific Regulations)

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

Module Responsible	Prof. Anusch Taraz
Admission Requirements	None
Recommended Previous Knowledge	see selected module accoording to FSPO
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	see selected module accoording to FSPO
Skills	see selected module accoording to FSPO
Personal Competence	
Social Competence	see selected module accoording to FSPO
Autonomy	see selected module accoording to FSPO
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Technomathematics: Specialisation IV. Subject Specific Focus: Elective Compulsory

Module M1957: Transferring Mathematics

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

Module Responsible	Dozenten der Mathematik
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 180, Study Time in Lecture 0
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	Report, 5-10 pages
Assignment for the Following Curricula	Technomathematics: Specialisation IV. Subject Specific Focus: Elective Compulsory

Thesis

Module M-001: Bachelor Thesis

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

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