



## **Module Manual**

Bachelor of Science (B.Sc.)

## **Technomathematics**

Cohort: Winter Term 2021

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# Table of Contents

Table of Contents	2
Program description	4
Core Qualification	5
Module M0577: Non-technical Courses for Bachelors	5
Module M1436: Procedural Programming for Computer Engineers	7
Module M0889: Mechanics I (Statics)	8
Module M0718: Linear Algebra for Technomathematicians	10
Module M0690: Analysis for Technomathematicians	12
Module M1519: Introduction to Electrical Engineering (Technomathematics)	14
Module M1432: Programming Paradigms	15
Module M1113: Proseminar Technomathematics	17
Module M1075: Numerical Mathematics	18
Module M1085: Mathematical Stochastics	20
Module M1074: Higher Analysis	22
Module M0829: Foundations of Management	25
Module M1114: Seminar Technomathematics	28
Specialization I. Mathematics	29
Module M1429: Complex Functions	29
Module M1052: Algebra	31
Module M0715: Solvers for Sparse Linear Systems	33
Module M1056: Functional Analysis	35
Module M0692: Approximation and Stability	37
Module M1062: Mathematical Statistics	39
Module M1079: Differential Geometry	41
Module M1080: Ordinary Differential Equations and Dynamical Systems	43
Module M1060: Optimization	45
Module M0852: Graph Theory and Optimization	47
Module M1061: Measure Theory and Stochastics	49
Module M0714: Numerical Treatment of Ordinary Differential Equations	51
Module M1083: Discrete Mathematics	53
Module M0716: Hierarchical Algorithms	55
Module M1020: Numerics of Partial Differential Equations	57
Module M0881: Mathematical Image Processing	59
Module M1063: Stochastic Processes	61
Module M1552: Mathematics of Neural Networks	63
Module M1059: Approximation	65
Module M1058: Introduction to Mathematical Modeling	67
Module M1078: Geometry	69
Module M1129: Mathematical Systems Theory	71
Module M0941: Combinatorial Structures and Algorithms	73
Module M1055: Complex Analysis	75
Module M1050: Graph Theory	77
Module M1051: Combinatorial Optimization	79
Module M0720: Matrix Algorithms	81
Module M0711: Numerical Mathematics II	83
Module M1053: Introductory Number Theory	85
Module M1086: Practical Statistics	87
Module M1054: Topology	89
Module M1556: Set Theory and Mathematical Logic	91
Module M1668: Probability Theory	93
Specialization II. Informatics	95
Module M0732: Software Engineering	95
Module M0624: Automata Theory and Formal Languages	97
Module M1586: Scientific Programming	99
Module M0730: Computer Engineering	101
Module M0834: Computernetworks and Internet Security	103
Module M0731: Functional Programming	105
Module M1423: Algorithms and Data Structures	107
Module M0625: Databases	109
Module M0668: Algebra and Control	111
Module M0754: Compiler Construction	113
Module M0562: Computability and Complexity Theory	115
Specialization III. Engineering Science	116
Module M0536: Fundamentals of Fluid Mechanics	116
Module M0634: Introduction into Medical Technology and Systems	118
Module M0680: Fluid Dynamics	120
Module M0757: Biochemistry and Microbiology	122
Module M1277: MED I: Introduction to Anatomy	126
Module M0938: Bioprocess Engineering - Fundamentals	128
Module M1278: MED I: Introduction to Radiology and Radiation Therapy	131
Module M0671: Technical Thermodynamics I	133

Module M0567: Theoretical Electrical Engineering I: Time-Independent Fields	135
Module M0672: Signals and Systems	137
Module M0706: Geotechnics I	140
Module M0610: Electrical Machines and Actuators	142
Module M0696: Mechanics II: Mechanics of Materials	144
Module M0580: Principles of Building Materials and Building Physics	146
Module M0687: Chemistry	148
Module M0740: Structural Analysis I	150
Module M0933: Fundamentals of Materials Science	152
Module M0808: Finite Elements Methods	154
Module M0945: Bioprocess Engineering - Advanced	156
Module M1279: MED II: Introduction to Biochemistry and Molecular Biology	158
Module M0783: Measurements: Methods and Data Processing	159
Module M0688: Technical Thermodynamics II	161
Module M0568: Theoretical Electrical Engineering II: Time-Dependent Fields	163
Module M0538: Heat and Mass Transfer	165
Module M0675: Introduction to Communications and Random Processes	167
Module M0959: Mechanics III (Dynamics)	169
Module M0655: Computational Fluid Dynamics I	171
Module M0833: Introduction to Control Systems	173
Module M1333: BIO I: Implants and Fracture Healing	176
Module M0708: Electrical Engineering III: Circuit Theory and Transients	178
Module M0755: Geotechnics II	180
Module M0807: Boundary Element Methods	182
Module M0734: Electrical Engineering Project Laboratory	184
Module M1280: MED II: Introduction to Physiology	185
Module M0805: Technical Acoustics I (Acoustic Waves, Noise Protection, Psycho Acoustics )	186
Module M1005: Enhanced Fundamentals of Materials Science	188
Module M0606: Numerical Algorithms in Structural Mechanics	192
Module M0594: Fundamentals of Mechanical Engineering Design	194
Module M0960: Mechanics IV (Oscillations, Analytical Mechanics, Multibody Systems, Numerical Mechanics)	196
Module M0777: Semiconductor Circuit Design	198
Module M1332: BIO I: Experimental Methods in Biomechanics	200
Module M0604: High-Order FEM	201
Module M1573: Modeling, Simulation and Optimization (EN)	203
Specialization IV. Subject Specific Focus	204
Module M1321: Technical Complementary Course I for Technomathematics (according to Subject Specific Regulations)	204
Module M1353: Mathematical Project Laboratory	205
Module M1322: Technical Complementary Course II for Technomathematics (according to Subject Specific Regulations)	206
Thesis	207
Module M-001: Bachelor Thesis	207

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## **Program description**

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### **Content**

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**Core Qualification**


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**Module M0577: Non-technical Courses for Bachelors**

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

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

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

**Module M1436: Procedural Programming for Computer Engineers****Courses**

<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Procedural Programming for Computer Engineers (L2163)	Lecture	1	2
Procedural Programming for Computer Engineers (L2164)	Recitation Section (large)	1	1
Procedural Programming for Computer Engineers (L2165)	Practical Course	2	3
<b>Module Responsible</b>	NN		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i> <i>Skills</i> <b>Personal Competence</b> <i>Social Competence</i> <i>Autonomy</i>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	120 min		
<b>Assignment for the Following Curricula</b>	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**

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

**Course L2164: Procedural Programming for Computer Engineers**

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

**Course L2165: Procedural Programming for Computer Engineers**

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

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

Course L1001: Mechanics I (Statics)	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Robert Seifried
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Tasks in Mechanics</li> <li>• Modelling and model elements</li> <li>• Vector calculus for forces and torques</li> <li>• Forces and equilibrium in space</li> <li>• Constraints and reactions, characterization of constraint systems</li> <li>• Planar and spatial truss structures</li> <li>• Internal forces and moments for beams and frames</li> <li>• Center of mass, volume, area and line</li> <li>• Computation of center of mass by integrals, joint bodies</li> <li>• Friction (sliding and sticking)</li> <li>• Friction of ropes</li> </ul>
<b>Literature</b>	<b>K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009).</b> <b>D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1. 11. Auflage, Springer (2011).</b>

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

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

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

Course L0587: Linear Algebra 1 for Technomathematicians	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	5
<b>Workload in Hours</b>	Independent Study Time 94, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Sabine Le Borne, Prof. Anusch Taraz
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Proof techniques, sets, relations, functions</li> <li>2. Groups and Fields</li> <li>3. Vector spaces</li> <li>4. Applications of vector spaces</li> <li>5. Linear mappings</li> <li>6. Polynomials</li> <li>7. Determinants</li> </ol>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• G. Fischer, Lineare Algebra: Eine Einführung für Studienanfänger</li> <li>• A. Beutelspacher: Lineare Algebra: Eine Einführung in die Wissenschaft der Vektoren, Abbildungen und Matrizen</li> <li>• J. Liesen, V. Mehrmann: Lineare Algebra: Ein Lehrbuch über die Theorie mit Blick auf die Praxis</li> <li>• G. Strang: Introduction to Linear Algebra</li> </ul>

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

Course L0589: Linear Algebra 2 for Technomathematicians	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	5
<b>Workload in Hours</b>	Independent Study Time 94, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Sabine Le Borne, Prof. Anusch Taraz
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Eigenvalues</li> <li>2. Bilinear forms</li> <li>3. Singular value decomposition</li> <li>4. Tensor products</li> <li>5. Application: Linear ordinary differential equations</li> </ol>
<b>Literature</b>	siehe Lineare Algebra 1 für Technomathematiker

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

Module M0690: Analysis for Technomathematicians				
Courses				
Title		Type	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	<div><div>Knowledge</div><div>Students are able to<ul style="list-style-type: none"><li>name, define and explain the basic properties of the field of real numbers,</li><li>define and interrelate the basic topological terms in a metric space,</li><li>in particular, describe their interrelation with the concepts of convergence and continuity,</li><li>define, explain and use the basic terms of differential calculus in several variables and integral calculus in one variable,</li></ul>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.</div><div>Skills</div><div>Students are able to<ul style="list-style-type: none"><li>determine topological properties of concrete sets in metric space,</li><li>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,</li><li>differentiate a function in one or several variables,</li><li>decide whether a given function is Riemann integrable and compute its integral,</li><li>compute Taylor polynomial and Taylor series of a given, sufficiently smooth, function in one or more variables,</li><li>find local and global extrema of a given function - possibly under constraints</li></ul></div><div>Personal Competence</div><div><div>Social Competence</div><div>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).</div><div>Autonomy</div><div>Students are able to<ul style="list-style-type: none"><li>gain further information from additional literature and put it in context with the contents of the lecture,</li><li>put their knowledge in relation to the contents of other lectures,</li><li>work on difficult problems over a long period.</li></ul></div></div></div>			
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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	5
<b>Workload in Hours</b>	Independent Study Time 94, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Marko Lindner, Prof. Sabine Le Borne, Prof. Matthias Schulte
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>logic, sets</li> <li>cardinalities</li> <li>numbers</li> <li>metric space and convergence</li> <li>continuity</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>K. Königsberger: Analysis I und II</li> <li>O. Forster: Analysis 1 und 2</li> <li>H. Heuser: Lehrbuch der Analysis. Teile 1 und 2</li> </ul>

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

Course L0485: Analysis II for Technomathematicians	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	5
<b>Workload in Hours</b>	Independent Study Time 94, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Marko Lindner, Prof. Sabine Le Borne
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• differentiation in 1D</li> <li>• integration in 1D</li> <li>• sequences and series of functions</li> <li>• differentiation in several variables</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• K. Königsberger: Analysis I und II</li> <li>• O. Forster: Analysis 1 und 2</li> <li>• H. Heuser: Lehrbuch der Analysis. Teile 1 und 2</li> </ul>

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

Module M1519: Introduction to Electrical Engineering (Technomathematics)				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Introduction to Electrical Engineering (Technomathematics) (L2292)		Lecture	3	4
Introduction to Electrical Engineering (Technomathematics) (L2293)		Recitation Section (small)	2	2
<b>Module Responsible</b>	Prof. Christian Kautz			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>				
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i> <i>Skills</i> <b>Personal Competence</b> <i>Social Competence</i> <i>Autonomy</i>				
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Subject theoretical and practical work			
<b>Examination duration and scale</b>	online exercises, short presentation, presence exercise, short oral exam			
<b>Assignment for the Following Curricula</b>	Technomathematics: Core Qualification: Compulsory			

Course L2292: Introduction to Electrical Engineering (Technomathematics)	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Christian Kautz
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	

Course L2293: Introduction to Electrical Engineering (Technomathematics)	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Christian Kautz
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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	NN			
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	<div><div>Knowledge</div><p>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.</p><div>Skills</div><p>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.</p><div>Personal Competence</div><div>Social Competence</div><p>Students can work in teams and communicate in forums.</p><div>Autonomy</div><p>In a programming internship, students learn object-oriented programming under supervision. In exercises they develop individual and independent solutions and receive feedback.</p></div>			
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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des SD E
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• fundamentals behind object orientated programming</li> <li>• classes and objects</li> <li>• inheritance (single, multiple)</li> <li>• interfaces</li> <li>• information hiding</li> <li>• exception handling</li> <li>• generic programming and the implementation in the compiler</li> <li>• excursus in programming with dynamically typed programming languages</li> </ul>
<b>Literature</b>	Skript

Course L2170: Programming Paradigms	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Dozenten des SD E
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• fundamentals behind object orientated programming</li> <li>• classes and objects</li> <li>• inheritance (single, multiple)</li> <li>• interfaces</li> <li>• information hiding</li> <li>• exception handling</li> <li>• generic programming and the implementation in the compiler</li> <li>• excursus in programming with dynamically typed programming languages</li> </ul>
<b>Literature</b>	Skript

Course L2171: Programming Paradigms	
<b>Typ</b>	Practical Course
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des SD E
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• fundamentals behind object orientated programming</li> <li>• classes and objects</li> <li>• inheritance (single, multiple)</li> <li>• interfaces</li> <li>• information hiding</li> <li>• exception handling</li> <li>• generic programming and the implementation in the compiler</li> <li>• excursus in programming with dynamically typed programming languages</li> </ul>
<b>Literature</b>	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	<ul style="list-style-type: none"><li>Analysis &amp; Linear Algebra I + II for Technomathematicians</li></ul> or <ul style="list-style-type: none"><li>Mathematik I + II (for Engineering Students - German or English lecture series), and</li><li>an advanced course by the lecturer who is responsible for the proseminar</li></ul>			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<div><div>Knowledge</div><div>Students acquire a deep understanding of the mathematical subject under consideration.</div></div> <div><div>Skills</div><div>Students are able to<ul style="list-style-type: none"><li>understand, analyze, classify and work on an advanced mathematical topic,</li><li>thoroughly study the recommended literature,</li><li>present their results in a mathematically correct and comprehensible way.</li></ul></div></div> <div><div>Personal Competence</div><div><div>Social Competence</div><div>Students are able to present their results in an appropriate way to the group.</div></div><div><div>Autonomy</div><div>Students are able to prepare a written scientific presentation on their own; in particular to<ul style="list-style-type: none"><li>find and critically check relevant literature,</li><li>make and incorporate their own thoughts,</li><li>complete the presentation in time.</li></ul></div></div></div>			
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	
<b>Typ</b>	Seminar
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Anusch Taraz, Prof. Sabine Le Borne, Prof. Marko Lindner, Dr. Christian Seifert, Prof. Heinrich Voß, Dozenten des Fachbereiches Mathematik der UHH, Dr. Mijail Guillemard, Dr. Julian Großmann, Dr. Haibo Ruan
<b>Language</b>	DE
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	<p>Selected topics from the fields</p> <ul style="list-style-type: none"> <li>Applied Analysis</li> <li>Numerical Linear Algebra</li> <li>Computational mathematics</li> <li>Discrete mathematics</li> </ul>
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Jens Struckmeier			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Linear Algebra Analysis			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>Students can describe basic concepts in Numerical Mathematics such as methods 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.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul>			
<i>Skills</i>				
<b>Personal Competence</b> <i>Social Competence</i>				
<i>Autonomy</i>				
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84			
<b>Credit points</b>	9			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 minutes			
<b>Assignment for the Following Curricula</b>	Technomathematics: Core Qualification: Compulsory			

Course L1357: Numerical Mathematics	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Linear systems of equations, error analysis</li> <li>• Interpolation by polynomials and splines</li> <li>• Orthogonalization methods, linear regression</li> <li>• Linear optimization, in particular simplex method</li> <li>• Numerical integration</li> <li>• Nonlinear equations</li> <li>• Eigenvalue problems</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• <b>Numerische Mathematik</b>, Jochen Werner, Vieweg, 1992</li> <li>• <b>Numerische Mathematik</b>, Robert Schaback, Holger Wendland, Auflage: 5., vollst. neu bearb. Aufl. 2005 (8. September 2004), <b>Sprache:</b> Deutsch, <b>ISBN-10:</b> 3540213945, <b>ISBN-13:</b> 978-3540213949</li> <li>• <b>Numerische Mathematik</b>, Hans-Rudolf Schwarz, Norbert Köckler, Vieweg+Teubner Verlag, 2011, <b>ISBN:</b> 3834815519 <b>ISBN:</b> 9783834815514</li> <li>• <b>Stoer/Bulirsch: Numerische Mathematik 1</b>, Roland Freund, Ronald Hoppe, Springer; Auflage: 10., neu bearb. Aufl. 2007 (18. April 2007), <b>Sprache:</b> Deutsch, <b>ISBN-10:</b> 354045389X, <b>ISBN-13:</b> 978-3540453895</li> <li>• <b>Numerische Mathematik I</b>, Peter Deuflhard, Andreas Hohmann, Gruyter; Auflage: 3., überarb. A. (18. April 2002), Deutsch, <b>ISBN-10:</b> 3110171821, <b>ISBN-13:</b> 978-3110171822</li> </ul>

Course L1358: Numerical Mathematics	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Holger Drees		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Analysis</li> <li>• Linear Algebra</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>• 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.</li> <li>• They are able to explain them using appropriate examples.</li> <li>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>• They know proof strategies and can reproduce them.</li> </ul>		
<i>Skills</i>	<ul style="list-style-type: none"> <li>• 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.</li> <li>• Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul>		
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>• Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>• In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul>		
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>• Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>• Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84		
<b>Credit points</b>	9		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	120 minutes		
<b>Assignment for the Following Curricula</b>	Technomathematics: Core Qualification: Compulsory		

Course L1392: Mathematical Stochastics	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Probability measures and random experiments</li> <li>• Random variables and pushforward measures, classification numbers of random variables and distributions</li> <li>• Multi-level models: Transition probabilities and stochastic independence</li> <li>• Law of large numbers and central limit theorem, Poisson's limit theorem</li> <li>• Measurable functions and general measure integral, application in stochastics</li> <li>• Treatment of selected problems of statistics, stochastic processes, insurance mathematics</li> <li>• Problems of stochastic modelling</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• K. Behnen und G. Neuhaus (2003). Grundkurs Stochastik (4. Aufl.). PD-Verlag</li> <li>• P. Billingsley (1995). Probability and Measure (3. ed.). Wiley.</li> <li>• H. Dehling und B. Haupt (2003). Einführung in die Wahrscheinlichkeitstheorie und Statistik. Springer.</li> <li>• C. Hesse (2003). Angewandte Wahrscheinlichkeitstheorie. Vieweg Verlag.</li> <li>• U. Krengel (2000). Einführung in die Wahrscheinlichkeitstheorie und Statistik. Vieweg.</li> </ul>

Course L1393: Mathematical Stochastics	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Vicente Cortés			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Analysis</li> <li>Linear Algebra</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>Students can describe basic concepts in Higher Analysis such as submanifolds, tangential bundles, Lebesgue integration theory, fundamentals of funktional analysis, the Hilbert space <math>L^2</math>, Fourier analysis, <math>L^p</math> spaces, classical inequalities and fundamentals of general measure and integration theory. They are able to explain them using appropriate examples.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul>			
<i>Skills</i>	<ul style="list-style-type: none"> <li>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.</li> <li>Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul>			
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul>			
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84			
<b>Credit points</b>	9			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 minutes			
<b>Assignment for the Following Curricula</b>	Technomathematics: Core Qualification: Compulsory			

Course L1355: Higher Analysis	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>Submanifolds of <math>\mathbb{R}^n</math></li> <li>Tangential bundles <ul style="list-style-type: none"> <li>Differential of differentiable mappings</li> <li>Integral theorems for submanifolds (in general form)</li> </ul> </li> <li>Lebesgue integration theory</li> <li>Fundamentals of funktional analysis</li> <li>Hilbert space <math>L^2</math> and Fourier analysis</li> <li><math>L^p</math> spaces</li> <li>Classical inequalities</li> <li>Fundamentals of general measure and integration theory</li> </ul>

Literature	<p><b>a) Vektoranalysis - Differentialformen in Analysis, Geometrie und Physik</b></p> <ul style="list-style-type: none"> <li>• Autoren: Ilka Agricola, Thomas Friedrich</li> <li>• Vieweg + Teubner Verlag, 2. Auflage, 2010</li> <li>• Sprache: Deutsch</li> <li>• ISBN-10: 3834810169</li> <li>• ISBN-13: 978-3834810168</li> </ul> <p><b>b) Analysis 3: Maß- und Integrationstheorie, Integralsätze im <math>\mathbb{R}^n</math> und Anwendungen</b> (Aufbaukurs Mathematik)</p> <ul style="list-style-type: none"> <li>• Autor: Otto Forster</li> <li>• Vieweg+Teubner Verlag; Auflage: 7., überarb. Aufl. 2012</li> <li>• Sprache: Deutsch</li> <li>• ISBN-10: 3834823732</li> <li>• ISBN-13: 978-3834823731</li> </ul> <p><b>c) Höhere Analysis,</b></p> <ul style="list-style-type: none"> <li>• Autor: R. Lauterbach</li> </ul> <p>(Skript, WS 09/10, verfügbar auf <a href="http://www.math.uni-hamburg.de/home/lauterbach/analysis3_WS0910.html#skript">http://www.math.uni-hamburg.de/home/lauterbach/analysis3_WS0910.html#skript</a>)</p> <p><b>d) Real and complex analysis</b></p> <ul style="list-style-type: none"> <li>• Autor: Walter Rudin</li> <li>• Verlag: Oldenbourg Wissenschaftsverlag (25. August 1999)</li> <li>• Sprache: Deutsch</li> <li>• ISBN-10: 3486247891</li> <li>• ISBN-13: 978-3486247893</li> </ul> <p><b>oder</b></p> <p><b>Real and complex analysis</b></p> <ul style="list-style-type: none"> <li>• Autor: Walter Rudin</li> <li>• McGraw-Hill, 1987 , 3. illustrierte Neuauflage</li> <li>• Sprache: Englisch</li> <li>• Digitalisiert: 2. Febr. 2010</li> <li>• ISBN: 0070542341, 9780070542341</li> </ul> <p><b>e) An Introduction to Measure Theory (Graduate Studies in Mathematics)</b></p> <ul style="list-style-type: none"> <li>• Autor: Terence Tao</li> <li>• Verlag: American Mathematical Society (15. September 2011)</li> <li>• Sprache: Englisch</li> <li>• ISBN-10: 0821869191</li> <li>• ISBN-13: 978-0821869192</li> </ul> <p><b>f) Maß- und Integrationstheorie</b></p> <ul style="list-style-type: none"> <li>• Autor: Heinz Bauer</li> <li>• Verlag: de Gruyter; Auflage: 2., überarb. A. (1. Juli 1992)</li> <li>• Sprache: Englisch</li> <li>• ISBN-10: 3110136252</li> <li>• ISBN-13: 978-3110136258</li> </ul> <p><b>g) Maß- und Integrationstheorie</b></p> <ul style="list-style-type: none"> <li>• Autor: Jürgen Elstrodt</li> <li>• Springer, 2004</li> <li>• ISBN-10: 3540213902</li> <li>• ISBN-13: 9783540213901</li> </ul>
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Course L1356: Higher Analysis	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Christoph Ihl			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic Knowledge of Mathematics and Business			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	<p>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</p> <ul style="list-style-type: none"> <li>explain the differences between Economics and Management and the sub-disciplines in Management and to name important definitions from the field of Management</li> <li>explain the most important aspects of and goals in Management and name the most important aspects of entrepreneurial projects</li> <li>describe and explain basic business functions as production, procurement and sourcing, supply chain management, organization and human resource management, information management, innovation management and marketing</li> <li>explain the relevance of planning and decision making in Business, esp. in situations under multiple objectives and uncertainty, and explain some basic methods from mathematical Finance</li> <li>state basics from accounting and costing and selected controlling methods.</li> </ul>			
<i>Skills</i>	<p>Students are able to analyse business units with respect to different criteria (organization, objectives, strategies etc.) and to carry out an Entrepreneurship project in a team. In particular, they are able to</p> <ul style="list-style-type: none"> <li>analyse Management goals and structure them appropriately</li> <li>analyse organisational and staff structures of companies</li> <li>apply methods for decision making under multiple objectives, under uncertainty and under risk</li> <li>analyse production and procurement systems and Business information systems</li> <li>analyse and apply basic methods of marketing</li> <li>select and apply basic methods from mathematical finance to predefined problems</li> <li>apply basic methods from accounting, costing and controlling to predefined problems</li> </ul>			
<b>Personal Competence</b>				
<i>Social Competence</i>	<p>Students are able to</p> <ul style="list-style-type: none"> <li>work successfully in a team of students</li> <li>to apply their knowledge from the lecture to an entrepreneurship project and write a coherent report on the project</li> <li>to communicate appropriately and</li> <li>to cooperate respectfully with their fellow students.</li> </ul>			
<i>Autonomy</i>	<p>Students are able to</p> <ul style="list-style-type: none"> <li>work in a team and to organize the team themselves</li> <li>to write a report on their project.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Subject theoretical and practical work			
<b>Examination duration and scale</b>	several written exams during the semester			
<b>Assignment for the Following Curricula</b>	<p>General Engineering Science (German program, 7 semester): Core Qualification: Compulsory            Civil- and Environmental Engineering: Specialisation Civil Engineering: Elective Compulsory            Civil- and Environmental Engineering: Specialisation Water and Environment: Elective Compulsory            Civil- and Environmental Engineering: Specialisation Traffic and Mobility: Elective Compulsory            Bioprocess Engineering: Core Qualification: Compulsory            Computer Science: Core Qualification: Compulsory            Data Science: Core Qualification: Compulsory            Electrical Engineering: Core Qualification: Compulsory            Energy and Environmental Engineering: Core Qualification: Compulsory            General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory            General Engineering Science (English program, 7 semester): Specialisation Civil Engineering: Compulsory            General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory            General Engineering Science (English program, 7 semester): Specialisation Energy and Environmental Engineering: Compulsory            General Engineering Science (English program, 7 semester): Specialisation Computer Science: Compulsory            General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory            General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory            General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory</p>			

	<p>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Naval Architecture: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory</p> <p>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory</p> <p>Computational Science and Engineering: Core Qualification: Compulsory</p> <p>Logistics and Mobility: Core Qualification: Compulsory</p> <p>Mechanical Engineering: Core Qualification: Compulsory</p> <p>Mechatronics: Core Qualification: Compulsory</p> <p>Orientation Studies: Core Qualification: Elective Compulsory</p> <p>Orientation Studies: Core Qualification: Elective Compulsory</p> <p>Naval Architecture: Core Qualification: Compulsory</p> <p>Technomathematics: Core Qualification: Compulsory</p> <p>Process Engineering: Core Qualification: Compulsory</p> <p>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory</p>
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Course L0882: Management Tutorial	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Christoph Ihl, Katharina Roedelius
<b>Language</b>	DE
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	<p>In the management tutorial, the contents of the lecture will be deepened by practical examples and the application of the discussed tools.</p> <p>If there is adequate demand, a problem-oriented tutorial will be offered in parallel, which students can choose alternatively. Here, students work in groups on selected projects that focus on the elaboration of an innovative business idea from the point of view of an established company or a startup. Again, the business knowledge from the lecture should come to practical use. The group projects are guided by a mentor.</p>
<b>Literature</b>	Relevante Literatur aus der korrespondierenden Vorlesung.

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

Module M1114: Seminar Technomathematics				
Courses				
Title	Typ		Hrs/wk	CP
Seminar: Technomathematics (L0920)	Seminar		2	4
<b>Module Responsible</b>	Prof. Anusch Taraz			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Analysis &amp; Linear Algebra I + II for Technomathematicians</li> </ul> <b>or</b> <ul style="list-style-type: none"> <li>Mathematik I + II (for Engineering Students - German or English lecture series), <b>and</b></li> <li>an advanced course by the lecturer who is responsible for the seminar</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> Students acquire a deep understanding of the mathematical subject under consideration.</p> <p><i>Skills</i> Students are able to</p> <ul style="list-style-type: none"> <li>understand, analyze, classify and work on an advanced mathematical topic,</li> <li>thoroughly study the recommended (and further) literature,</li> <li>write down and present their results in a mathematically correct and comprehensible way.</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students are able to present their results in an appropriate way to the group.</p> <p><i>Autonomy</i> Students are able to prepare a written scientific report on their own; in particular to</p> <ul style="list-style-type: none"> <li>find and critically check relevant literature,</li> <li>make and incorporate their own thoughts,</li> <li>finish in time.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28			
<b>Credit points</b>	4			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	0 %	Written elaboration	
<b>Examination</b>	Presentation			
<b>Examination duration and scale</b>	60 Minutes			
<b>Assignment for the Following Curricula</b>	Technomathematics: Core Qualification: Compulsory			

Course L0920: Seminar: Technomathematics	
<b>Typ</b>	Seminar
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Christian Seifert, Dozenten des Fachbereiches Mathematik der UHH, Dozenten der Mathematik
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	<p>Selected topics from the fields</p> <ul style="list-style-type: none"> <li>Applied Analysis</li> <li>Computational mathematics</li> <li>Discrete mathematics</li> <li>Mathematical Optimization</li> </ul>
<b>Literature</b>	wird in der Lehrveranstaltung bekannt gegeben

## Specialization I. Mathematics

### 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
<b>Module Responsible</b>	Prof. Timo Reis		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Analysis, Higher Analysis, Linear Algebra		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i> <i>Skills</i> <b>Personal Competence</b> <i>Social Competence</i> <i>Autonomy</i>			
<b>Workload in Hours</b>	Independent Study Time 34, Study Time in Lecture 56		
<b>Credit points</b>	3		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory		

#### Course L1038: Complex Functions

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

#### Course L1042: Complex Functions

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

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

Module M1052: Algebra				
Courses				
Title	Typ		Hrs/wk	CP
Algebra (L1317)	Lecture		4	6
Algebra (L1318)	Recitation Section (small)		2	3
<b>Module Responsible</b>	Prof. Christoph Schweigert			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Linear Algebra			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>Students can name the basic concepts in Algebra such as groups, rings and modules. They are able to explain them using appropriate examples.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul>			
<i>Skills</i>				
<b>Personal Competence</b> <i>Social Competence</i>				
<i>Autonomy</i>				
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84			
<b>Credit points</b>	9			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 min			
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory			

Course L1317: Algebra	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	<ul style="list-style-type: none"> <li>Jantzen, Schwermer, "Algebra" (Springer)</li> <li>Artin, "Algebra" (Birkhäuser)</li> <li>Bosch, "Algebra" (Springer)</li> <li>Lang, "Algebra" (Springer)</li> </ul>

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

Module M0715: Solvers for Sparse Linear Systems				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Solvers for Sparse Linear Systems (L0583)		Lecture	2	3
Solvers for Sparse Linear Systems (L0584)		Recitation Section (small)	2	3
<b>Module Responsible</b>	Prof. Sabine Le Borne			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Mathematics I + II for Engineering students or Analysis &amp; Lineare Algebra I + II for Technomathematicians</li> <li>Programming experience in C</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i></p> <p>Students can</p> <ul style="list-style-type: none"> <li>list classical and modern iteration methods and their interrelationships,</li> <li>repeat convergence statements for iterative methods,</li> <li>explain aspects regarding the efficient implementation of iteration methods.</li> </ul> <p><i>Skills</i></p> <p>Students are able to</p> <ul style="list-style-type: none"> <li>analyse, implement, test, and compare iterative methods,</li> <li>analyse the convergence behaviour of iterative methods and, if applicable, compute convergence rates.</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i></p> <p>Students are able to</p> <ul style="list-style-type: none"> <li>work together in heterogeneously composed teams (i.e., teams from different study programs and background knowledge), explain theoretical foundations and support each other with practical aspects regarding the implementation of algorithms.</li> </ul> <p><i>Autonomy</i></p> <p>Students are capable</p> <ul style="list-style-type: none"> <li>to assess whether the supporting theoretical and practical exercises are better solved individually or in a team,</li> <li>to work on complex problems over an extended period of time,</li> <li>to assess their individual progress and, if necessary, to ask questions and seek help.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	20 min			
<b>Assignment for the Following Curricula</b>	Computer Science: Specialisation Computational Mathematics: Elective Compulsory 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 Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory			

Course L0583: Solvers for Sparse Linear Systems	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Sabine Le Borne
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ol style="list-style-type: none"> <li>Sparse systems: Orderings and storage formats, direct solvers</li> <li>Classical methods: basic notions, convergence</li> <li>Projection methods</li> <li>Krylov space methods</li> <li>Preconditioning (e.g. ILU)</li> <li>Multigrid methods</li> <li>Domain Decomposition Methods</li> </ol>
<b>Literature</b>	<ol style="list-style-type: none"> <li>Y. Saad. Iterative methods for sparse linear systems</li> <li>M. Olshanskii, E. Tyrtshnikov. Iterative methods for linear systems: theory and applications</li> </ol>

Course L0584: Solvers for Sparse Linear Systems	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Sabine Le Borne
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Reiner Lauterbach		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Linear Algebra</li> <li>Analysis</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>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.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul>		
<i>Skills</i>	<ul style="list-style-type: none"> <li>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.</li> <li>Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul>		
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul>		
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84		
<b>Credit points</b>	9		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory		

Course L1327: Functional Analysis	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Normed, Banach and Hilbert spaces</li> <li>• Baire's category theorem and implications (fundamental principles)</li> <li>• Linear operators, dual spaces</li> <li>• classical function spaces</li> <li>• Hahn-Banach theorem, (non-)compactness</li> <li>• Spectrum, compact operators</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Alt, <b>Lineare Funktionalanalysis -Eine anwendungsorientierte Einführung</b>, Springer, 2012</li> <li>• Werner, <b>Funktionalanalysis</b>, Springer, 2011</li> <li>• Rudin, <b>Functional analysis</b>, McGraw-Hill, 1973</li> <li>• Adams, <b>Sobolev spaces</b>, Academic press, 1975</li> </ul>

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

Module M0692: Approximation and Stability				
<b>Courses</b>				
<b>Title</b>	<b>Typ</b>		<b>Hrs/wk</b>	<b>CP</b>
Approximation and Stability (L0487)	Lecture		3	4
Approximation and Stability (L0488)	Recitation Section (small)		1	2
<b>Module Responsible</b>	Prof. Marko Lindner			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Linear Algebra: systems of linear equations, least squares problems, eigenvalues, singular values</li> <li>Analysis: sequences, series, differentiation, integration</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i></p> <p>Students are able to</p> <ul style="list-style-type: none"> <li>sketch and interrelate basic concepts of functional analysis (Hilbert space, operators),</li> <li>name and understand concrete approximation methods,</li> <li>name and explain basic stability theorems,</li> <li>discuss spectral quantities, conditions numbers and methods of regularisation</li> </ul> <p><i>Skills</i></p> <p>Students are able to</p> <ul style="list-style-type: none"> <li>apply basic results from functional analysis,</li> <li>apply approximation methods,</li> <li>apply stability theorems,</li> <li>compute spectral quantities,</li> <li>apply regularisation methods.</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i></p> <p>Students are able to solve specific problems in groups and to present their results appropriately (e.g. as a seminar presentation).</p> <p><i>Autonomy</i></p> <ul style="list-style-type: none"> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	None	Presentation	
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	20 min			
<b>Assignment for the Following Curricula</b>	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: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory			

Course L0487: Approximation and Stability	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Marko Lindner
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>This course is about solving the following basic problems of Linear Algebra,</p> <ul style="list-style-type: none"> <li>• systems of linear equations,</li> <li>• least squares problems,</li> <li>• eigenvalue problems</li> </ul> <p>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.</p> <p><b>Contents:</b></p> <ul style="list-style-type: none"> <li>• crash course on Hilbert spaces: metric, norm, scalar product, completeness</li> <li>• crash course on operators: boundedness, norm, compactness, projections</li> <li>• uniform vs. strong convergence, approximation methods</li> <li>• applicability and stability of approximation methods, Polski's theorem</li> <li>• Galerkin methods, collocation, spline interpolation, truncation</li> <li>• convolution and Toeplitz operators</li> <li>• crash course on <math>C^*</math>-algebras</li> <li>• convergence of condition numbers</li> <li>• convergence of spectral quantities: spectrum, eigen values, singular values, pseudospectra</li> <li>• regularisation methods (truncated SVD, Tichonov)</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• R. Hagen, S. Roch, B. Silbermann: <math>C^*</math>-Algebras in Numerical Analysis</li> <li>• H. W. Alt: Lineare Funktionalanalysis</li> <li>• M. Lindner: Infinite matrices and their finite sections</li> </ul>

Course L0488: Approximation and Stability	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Marko Lindner
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Natalie Neumeyer			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Mathematical Stochastics Measure Theory and Stochastics			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>Students 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.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul>			
<i>Skills</i>				
<b>Personal Competence</b> <i>Social Competence</i>				
<i>Autonomy</i>				
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 minutes			
<b>Assignment for the Following Curricula</b>	General Engineering Science (English program, 7 semester): Specialisation Computer Science: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory			

Course L1339: Mathematical Statistics	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>Substitution and Maximum-Likelihood methods for construction of estimators</li> <li>Optimal unfalsified estimators</li> <li>Optimal tests for parametric probability distributions (Neymann-Pearson theory)</li> <li>Sufficiency and completeness and their application to estimation and test problems</li> <li>Tests in normal distribution (e.g. Student's test)</li> <li>Confidence domains and test families</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>V. K. Rohatgi and A. K. Ehsanes Saleh (2001). <b>An introduction to probability and statistics</b>. Wiley.</li> <li>L. Wasserman (2010). <b>All of statistics : A concise course in statistical inference</b>. Springer.</li> <li>H. Witting (1985). <b>Mathematische Statistik: Parametrische Verfahren bei festem Stichprobenumfang</b>. Teubner.</li> </ul>

Course L1340: Mathematical Statistics	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Vicente Cortés			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Analysis</li> <li>• Higher Analysis</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>• 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.</li> <li>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>• They know proof strategies and can reproduce them.</li> </ul>			
<i>Skills</i>	<ul style="list-style-type: none"> <li>• 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.</li> <li>• Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul>			
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>• Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>• In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul>			
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>• Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>• Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84			
<b>Credit points</b>	9			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 min			
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory			

Course L1365: Differential Geometry	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Curves in the Euclidean space</li> <li>• Introduction to differentiable manifolds</li> <li>• Hyperplanes in the Euclidean space</li> <li>• Surfaces</li> <li>• Geodesy in Riemannian manifolds</li> <li>• Riemannian manifolds with constant curvature</li> </ul>
<b>Literature</b>	Manfredo Perdigão do Carmo: <b>Riemannian geometry</b> , Birkhäuser, 1992. Takashi Sakai, <b>Riemannian geometry</b> , AMS, 1996. Frank Warner, <b>Foundations of differentiable manifolds and Lie groups</b> , Springer, 1983.

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

Module M1080: Ordinary Differential Equations and Dynamical Systems			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Ordinary Differential Equations and Dynamical Systems (L1367)	Lecture	4	6
Ordinary Differential Equations and Dynamical Systems (L1368)	Recitation Section (small)	2	3
<b>Module Responsible</b>	Prof. Reiner Lauterbach		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Analysis</li> <li>• Higher Analysis</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>• 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.</li> <li>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>• They know proof strategies and can reproduce them.</li> </ul>		
<i>Skills</i>	<ul style="list-style-type: none"> <li>• Students can model problems in Ordinary differential equations and dynamical systems with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods.</li> <li>• Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul>		
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>• Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>• In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul>		
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>• Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>• Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84		
<b>Credit points</b>	9		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory		

Course L1367: Ordinary Differential Equations and Dynamical Systems	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Modelling with dynamical systems</li> <li>• Ordinary differential equations as dynamical systems (existence, uniqueness)</li> <li>• Long time behavior of orbits (predictability, periodicity, stability, limit sets, attractors)</li> <li>• Hyperbolic systems, linear differential equations and linearisations</li> <li>• Structural stability and bifurcations</li> <li>• Symbolic dynamics</li> <li>• Hamilton systems, ergodic systems</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• H. Amann, <b>Gewöhnliche Differentialgleichungen</b>, de Gruyter 1995</li> <li>• C. Chicone, <b>Ordinary Differential Equations with Applications</b>, Springer 2006.</li> <li>• H. Heuser, <b>Gewöhnliche Differentialgleichungen</b>, Teubner 2009.</li> <li>• M. Hirsch, <b>S. Smale, R. Devaney, Differential equations, dynamical systems, and an introduction to chaos</b>, Elsevier 2004.</li> <li>• W. Walter, <b>Gewöhnliche Differentialgleichungen</b>, Springer 2000.</li> </ul>

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

Module M1060: Optimization			
Courses			
Title	Typ	Hrs/wk	CP
Optimization (L1333)	Lecture	4	6
Optimization (L1334)	Recitation Section (small)	2	3
<b>Module Responsible</b>	Prof. Armin Iske		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Linear Algebra Analysis		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>Students 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.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul>		
<i>Skills</i>			
<b>Personal Competence</b> <i>Social Competence</i>			
<i>Autonomy</i>			
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84		
<b>Credit points</b>	9		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory		

Course L1333: Optimization	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• real world Examples</li> <li>• non-restricted optimization               <ul style="list-style-type: none"> <li>◦ necessary and sufficient conditions for optimality</li> <li>◦ globally convergent descent methods, (e.g gradient methods, Trust-Region-methods)</li> <li>◦ locally fast convergent methods (e.g. Newton and quasi-Newton-methods)</li> <li>◦ locally and globally fast convergent methods (e.g. globalised Newton-method)</li> </ul> </li> <li>• restricted optimization               <ul style="list-style-type: none"> <li>◦ necessary and sufficient conditions for optimality</li> <li>◦ numerical methods (e.g. Penalty-method, SQP-method)</li> <li>◦ Selected topics (e.g. convex optimization, duality, parametric optimization)</li> </ul> </li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Ulbrich, M. and Ulbrich, S., <b>Nichtlineare Optimierung</b>, Verlag Birkhäuser Basel 2012</li> <li>• C. Geiger and C. Kanzow, <b>Numerische Verfahren zur Lösung unrestringierter Optimierungsaufgaben</b>, Verlag Springer Berlin Heidelberg, 1999</li> <li>• C. Geiger and C. Kanzow, <b>Theorie und Numerik restringierter Optimierungsaufgaben</b>, Verlag Springer Berlin Heidelberg, 2002</li> <li>• J. Nocedal and S. J. Wright, <b>Numerical Optimization</b>, Verlag: Springer, 1999</li> <li>• D. P. Bertsekas, <b>Nonlinear Programming</b>, Publisher: Athena Scientific, 1999, 2nd Edition</li> </ul>

Course L1334: Optimization	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Anusch Taraz		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Discrete Algebraic Structures</li> <li>Mathematics I</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>Students can name the basic concepts in Graph Theory and Optimization. They are able to explain them using appropriate examples.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul>		
<i>Skills</i>	<ul style="list-style-type: none"> <li>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.</li> <li>Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul>		
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul>		
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	120 min		
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Computer Science: 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Anusch Taraz
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Graphs, search algorithms for graphs, trees</li> <li>• planar graphs</li> <li>• shortest paths</li> <li>• minimum spanning trees</li> <li>• maximum flow and minimum cut</li> <li>• theorems of Menger, König-Egervary, Hall</li> <li>• NP-complete problems</li> <li>• backtracking and heuristics</li> <li>• linear programming</li> <li>• duality</li> <li>• integer linear programming</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• M. Aigner: Diskrete Mathematik, Vieweg, 2004</li> <li>• T. Cormen, Ch. Leiserson, R. Rivest, C. Stein: Algorithmen - Eine Einführung, Oldenbourg, 2013</li> <li>• J. Matousek und J. Nešetřil: Diskrete Mathematik, Springer, 2007</li> <li>• A. Steger: Diskrete Strukturen (Band 1), Springer, 2001</li> <li>• A. Taraz: Diskrete Mathematik, Birkhäuser, 2012</li> <li>• V. Turau: Algorithmische Graphentheorie, Oldenbourg, 2009</li> <li>• K.-H. Zimmermann: Diskrete Mathematik, BoD, 2006</li> </ul>

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

Module M1061: Measure Theory and Stochastics			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b> <b>CP</b>
Measure Theory and Stochastics (L1335)		Lecture	3                  4
Measure Theory and Stochastics (L1338)		Recitation Section (small)	1                  2
<b>Module Responsible</b>	Prof. Holger Drees		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Mathematical Stochastics		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>Students can describe basic concepts in Stochastics such 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.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul>		
<i>Skills</i>	<ul style="list-style-type: none"> <li>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.</li> <li>Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul>		
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul>		
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory		

Course L1335: Measure Theory and Stochastics	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>General densities, Radon-Nikodym theorem</li> <li>Conditional expectation, Markov kernels</li> <li>Martingals in discrete time</li> <li>Convergence of probability measures</li> <li>Integral transformations (e.g. generating functions, Fourier transformation, Laplace transformation)</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>H. Bauer, <b>Maß- und Integrationstheorie</b>, de Gruyter Lehrbuch, Auflage: 2., überarb. A. (1. Juli 1992)</li> <li>H. Bauer, <b>Wahrscheinlichkeitstheorie</b>, de Gruyter Lehrbuch, Verlag: de Gruyter; Auflage: 5. durchges. und verb. (2002)</li> <li>J. Estrodt, <b>Maß- und Integrationstheorie</b>, Springer, 7., korrigierte und aktualisierte Auflage 2011</li> </ul>

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

Module M0714: Numerical Treatment of Ordinary Differential Equations				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Numerical Treatment of Ordinary Differential Equations (L0576)		Lecture	2	3
Numerical Treatment of Ordinary Differential Equations (L0582)		Recitation Section (small)	2	3
<b>Module Responsible</b>	Prof. Daniel Ruprecht			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Mathematik I, II, III für Ingenieurstudierende (deutsch oder englisch) oder Analysis &amp; Lineare Algebra I + II sowie Analysis III für Technomathematiker</li> <li>Basic MATLAB knowledge</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> Students are able to</p> <ul style="list-style-type: none"> <li>list numerical methods for the solution of ordinary differential equations and explain their core ideas,</li> <li>repeat convergence statements for the treated numerical methods (including the prerequisites tied to the underlying problem),</li> <li>explain aspects regarding the practical execution of a method.</li> <li>select the appropriate numerical method for concrete problems, implement the numerical algorithms efficiently and interpret the numerical results</li> </ul> <p><i>Skills</i> Students are able to</p> <ul style="list-style-type: none"> <li>implement (MATLAB), apply and compare numerical methods for the solution of ordinary differential equations,</li> <li>to justify the convergence behaviour of numerical methods with respect to the posed problem and selected algorithm,</li> <li>for a given problem, develop a suitable solution approach, if necessary by the composition of several algorithms, to execute this approach and to critically evaluate the results.</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students are able to</p> <ul style="list-style-type: none"> <li>work together in heterogeneously composed teams (i.e., teams from different study programs and background knowledge), explain theoretical foundations and support each other with practical aspects regarding the implementation of algorithms.</li> </ul> <p><i>Autonomy</i> Students are capable</p> <ul style="list-style-type: none"> <li>to assess whether the supporting theoretical and practical exercises are better solved individually or in a team,</li> <li>to assess their individual progress and, if necessary, to ask questions and seek help.</li> </ul>			
<b>Workload in Hours</b>				
<b>Credit points</b>				
<b>Course achievement</b>				
<b>Examination</b>				
<b>Examination duration and scale</b>				
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Daniel Ruprecht
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Numerical methods for Initial Value Problems</p> <ul style="list-style-type: none"> <li>• single step methods</li> <li>• multistep methods</li> <li>• stiff problems</li> <li>• differential algebraic equations (DAE) of index 1</li> </ul> <p>Numerical methods for Boundary Value Problems</p> <ul style="list-style-type: none"> <li>• multiple shooting method</li> <li>• difference methods</li> <li>• variational methods</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• E. Hairer, S. Noersett, G. Wanner: Solving Ordinary Differential Equations I: Nonstiff Problems</li> <li>• E. Hairer, G. Wanner: Solving Ordinary Differential Equations II: Stiff and Differential-Algebraic Problems</li> </ul>

Course L0582: Numerical Treatment of Ordinary Differential Equations	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Daniel Ruprecht
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Matthias Schacht		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Linear Algebra Geometry Analysis		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>Students 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.</li> <li>They are able to explain them using appropriate examples.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul>		
<i>Skills</i>			
<b>Personal Competence</b> <i>Social Competence</i>			
<i>Autonomy</i>			
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84		
<b>Credit points</b>	9		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory		

Course L1379: Discrete Mathematics	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction to discrete mathematics</li> <li>• Topics: <ul style="list-style-type: none"> <li>◦ Combinatorial problems and counting coefficients</li> <li>◦ Sorting algorithms</li> <li>◦ Fundamentals of graph theory</li> <li>◦ Graph and Network algorithms</li> <li>◦ Complexity</li> <li>◦ Asymptotic analysis</li> <li>◦ Diskrete probability distributions</li> <li>◦ Generating functions (ring of formal power series)</li> <li>◦ Inclusion and exklusion principle</li> <li>◦ ordered sets (Möbius inversion)</li> <li>◦ Counting of trees and patterns</li> <li>◦ Fundamentals in coding theory or cryptography</li> </ul> </li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• M. Aigner: Diskrete Mathematik, Vieweg, 6., korr. Aufl. 2006</li> <li>• L. Lovász, J. Pelikan &amp; K. Vesztegombi Diskrete Mathematik, Springer, 2005</li> <li>• J. Matoušek &amp; J. Nešetřil: Diskrete Mathematik - Eine Entdeckungsreise, Springer, 2007</li> <li>• A. Steger: Diskrete Strukturen - Band 1: Kombinatorik, Graphentheorie, Algebra, Springer, 2. Aufl. 2007</li> <li>• A. Taraz: Diskrete Mathematik - Grundlagen und Methoden, Birkhäuser, 2012</li> </ul>

Course L1380: Discrete Mathematics	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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	<ul style="list-style-type: none"><li>Mathematics I, II, III for Engineering students (german or english) or Analysis &amp; Linear Algebra I + II as well as Analysis III for Technomathematicians</li><li>Programming experience in C</li></ul>			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<div><div>Knowledge</div><div>Students are able to<ul style="list-style-type: none"><li>name representatives of hierarchical algorithms and list their characteristics,</li><li>explain construction techniques for hierarchical algorithms,</li><li>discuss aspects regarding the efficient implementation of hierarchical algorithms.</li></ul></div><div><div>Skills</div><div>Students are able to<ul style="list-style-type: none"><li>implement the hierarchical algorithms discussed in the lecture,</li><li>analyse the storage and computational complexities of the algorithms,</li><li>adapt algorithms to problem settings of various applications and thus develop problem adapted variants.</li></ul></div><div><div>Personal Competence</div><div><div>Social Competence</div><div>Students are able to<ul style="list-style-type: none"><li>work together in heterogeneously composed teams (i.e., teams from different study programs and background knowledge), explain theoretical foundations and support each other with practical aspects regarding the implementation of algorithms.</li></ul></div><div><div>Autonomy</div><div>Students are capable<ul style="list-style-type: none"><li>to assess whether the supporting theoretical and practical excercises are better solved individually or in a team,</li><li>to work on complex problems over an extended period of time,</li><li>to assess their individual progress and, if necessary, to ask questions and seek help.</li></ul></div></div></div></div></div></div>			
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 Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory			

Course L0585: Hierarchical Algorithms	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Sabine Le Borne
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>Low rank matrices</li> <li>Separable expansions</li> <li>Hierarchical matrix partitions</li> <li>Hierarchical matrices</li> <li>Formatted matrix operations</li> <li>Applications</li> <li>Additional topics (e.g. H2 matrices, matrix functions, tensor products)</li> </ul>
<b>Literature</b>	W. Hackbusch: Hierarchische Matrizen: Algorithmen und Analysis

Course L0586: Hierarchical Algorithms	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Sabine Le Borne
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1020: Numerics of Partial Differential Equations				
<b>Courses</b>				
<b>Title</b>			<b>Typ</b>	<b>Hrs/wk</b>
Numerics of Partial Differential Equations (L1247)			Lecture	2
Numerics of Partial Differential Equations (L1248)			Recitation Section (small)	2
<b>Module Responsible</b>	Prof. Daniel Ruprecht			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Mathematik I - IV (for Engineering Students) <b>or</b> Analysis &amp; Linear Algebra I + II for Technomathematicians</li> <li>Numerical mathematics 1</li> <li>Numerical treatment of ordinary differential equations</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i></p> <ul style="list-style-type: none"> <li>Students can classify partial differential equations according to the three basic types.</li> <li>For each type, students know suitable numerical approaches.</li> <li>Students know the theoretical convergence results for these approaches.</li> </ul> <p><i>Skills</i></p> <p>Students are capable to formulate solution strategies for given problems involving partial differential equations, to comment on theoretical properties concerning convergence and to implement and test these methods in practice.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i></p> <p>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.</p> <p><i>Autonomy</i></p> <ul style="list-style-type: none"> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>			
<i>Knowledge</i>				
<i>Skills</i>				
<i>Autonomy</i>				
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	25 min			
<b>Assignment for the Following Curricula</b>	Computer Science: Specialisation III. Mathematics: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory			

Course L1247: Numerics of Partial Differential Equations	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Daniel Ruprecht
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	Elementary Theory and Numerics of PDEs <ul style="list-style-type: none"> <li>types of PDEs</li> <li>well posed problems</li> <li>finite differences</li> <li>finite elements</li> <li>finite volumes</li> <li>applications</li> </ul>
<b>Literature</b>	Dietrich Braess: Finite Elemente: Theorie, schnelle Löser und Anwendungen in der Elastizitätstheorie, Berlin u.a., Springer 2007  Susanne Brenner, Ridgway Scott: The Mathematical Theory of Finite Element Methods, Springer, 2008  Peter Deufhard, Martin Weiser: Numerische Mathematik 3

Course L1248: Numerics of Partial Differential Equations	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Daniel Ruprecht
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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	<ul style="list-style-type: none"><li>Analysis: partial derivatives, gradient, directional derivative</li><li>Linear Algebra: eigenvalues, least squares solution of a linear system</li></ul>		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	<div>Knowledge</div> <p>Students are able to</p> <ul style="list-style-type: none"><li>characterize and compare diffusion equations</li><li>explain elementary methods of image processing</li><li>explain methods of image segmentation and registration</li><li>sketch and interrelate basic concepts of functional analysis</li></ul> <div>Skills</div> <p>Students are able to</p> <ul style="list-style-type: none"><li>implement and apply elementary methods of image processing</li><li>explain and apply modern methods of image processing</li></ul> <div>Personal Competence</div> <div>Social Competence</div> <p>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.</p> <div>Autonomy</div> <ul style="list-style-type: none"><li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li><li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li></ul>		
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 Computational Science and Engineering: Specialisation III. Mathematics: Elective Compulsory Interdisciplinary Mathematics: Specialisation Computational Methods in Biomedical Imaging: Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory		

Course L0991: Mathematical Image Processing	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Marko Lindner
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>basic methods of image processing</li> <li>smoothing filters</li> <li>the diffusion / heat equation</li> <li>variational formulations in image processing</li> <li>edge detection</li> <li>de-convolution</li> <li>inpainting</li> <li>image segmentation</li> <li>image registration</li> </ul>
<b>Literature</b>	Bredies/Lorenz: Mathematische Bildverarbeitung

Course L0992: Mathematical Image Processing	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Marko Lindner
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Holger Drees		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Mathematical Stochastics Measure Theory and Stochastics		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>Students 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.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul>		
<i>Skills</i>			
<b>Personal Competence</b> <i>Social Competence</i>			
<i>Autonomy</i>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory		

Course L1343: Stochastic Processes	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Classification and construction of stochastic processes, existence theorems</li> <li>• Markov processes with discrete state space in discrete and continuous time</li> <li>• Renewal theory</li> <li>• General Markov processes and Markov semigroups</li> <li>• Poisson processes, Brownian motion</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Asmussen, S.: Applied Probability and Queues, 2.ed., Springer, New York 2003</li> <li>• Chung, K.L.: Markov Chains, 2.ed., Springer Berlin 1967</li> <li>• Grimmett, G.; Stirzaker, D.R.: Probability and Random Processes, 3.ed., Oxford University Press, Oxford 2009</li> <li>• Karlin, S.; Taylor, H.M.: A First Course in Stochastic Processes, 2.ed., Academic Press, New York 1975</li> <li>• Resnick, S.I.: Adventures in Stochastic Processes, 2.pr., Birkhäuser, Boston 1994</li> <li>• Stroock, D.W.: An Introduction to Markov Processes, Springer, New York 2005</li> </ul>

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

Module M1552: Mathematics of Neural Networks			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Mathematics of Neural Networks (L2322)	Lecture	2	3
Mathematics of Neural Networks (L2323)	Recitation Section (small)	2	3
<b>Module Responsible</b>	Dr. Jens-Peter Zemke		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	1. Mathematics I-III 2. Numerical Mathematics 1/ Numerics 3. Programming skills, preferably in Python		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	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.  Students are able to implement, understand, and, tailored to the field of application, apply neural networks.  Students can <ul style="list-style-type: none"> <li>develop and document joint solutions in small teams;</li> <li>form groups to further develop the ideas and transfer them to other areas of applicability;</li> <li>form a team to develop, build, and advance a software library.</li> </ul>		
<i>Knowledge</i>			
<i>Skills</i>			
<b>Personal Competence</b>			
<i>Social Competence</i>	Students are able to <ul style="list-style-type: none"> <li>correctly assess the time and effort of self-defined work;</li> <li>assess whether the supporting theoretical and practical exercises are better solved individually or in a team;</li> <li>define test problems for testing and expanding the methods;</li> <li>assess their individual progress and, if necessary, to ask questions and seek help.</li> </ul>		
<i>Autonomy</i>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	25 min		
<b>Assignment for the Following Curricula</b>	Computer Science: Specialisation III. Mathematics: Elective Compulsory Computational Science and Engineering: Specialisation III. Mathematics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Technical Complementary Course: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory		

Course L2322: Mathematics of Neural Networks	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Jens-Peter Zemke
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	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
<b>Literature</b>	1. Skript 2. Online-Werke: <ul style="list-style-type: none"> <li><a href="http://neuralnetworksanddeeplearning.com/">http://neuralnetworksanddeeplearning.com/</a></li> <li><a href="https://www.deeplearningbook.org/">https://www.deeplearningbook.org/</a></li> </ul>

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

Module M1059: Approximation					
<b>Courses</b>					
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>	
Approximation (L1331)		Lecture	4	6	
Approximation (L1332)		Recitation Section (small)	2	3	
<b>Module Responsible</b>	Prof. Armin Iske				
<b>Admission Requirements</b>	None				
<b>Recommended Previous Knowledge</b>	Linear Algebra Analysis Introduction to Numerical Analysis				
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results				
<b>Professional Competence</b> <i>Knowledge</i>        <i>Skills</i>        <b>Personal Competence</b> <i>Social Competence</i>        <i>Autonomy</i>	<ul style="list-style-type: none"> <li>Students can describe basic concepts in Approximation such as L<sup>2</sup> 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.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul> <ul style="list-style-type: none"> <li>Students can model problems in Approximation with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods.</li> <li>Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul> <ul style="list-style-type: none"> <li>Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul> <ul style="list-style-type: none"> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>				
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84				
<b>Credit points</b>	9				
<b>Course achievement</b>	None				
<b>Examination</b>	Oral exam				
<b>Examination duration and scale</b>	30 min				
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory				

Course L1331: Approximation	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• <math>L^2</math> approximation</li> <li>• Tschebychev approximation and Remez methods</li> <li>• Approximation of periodic functions, Fourier series</li> <li>• Interpolation and approximation by splines</li> <li>• Representation of curves and surfaces</li> <li>• Wavelets and radial basis functions</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• DeVore, Ronald A. und Lorentz, George G.: Constructive Approximation, Springer, 1993.</li> <li>• Powell, Michael J. D.: Approximation theory and methods, Cambridge University Press, 1981.</li> <li>• Cheney, Elliot W. und Light, William A.: A course in approximation theory, Brooks/Cole Publishing, 2000.</li> </ul>

Course L1332: Approximation	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Ingenuin Gasser		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Analysis</li> <li>• Linear Algebra</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>• Students can describe basic concepts in Mathematical Modeling such as the modelling process, deterministic and stochastic models, modelling of dynamic processes, and discrete and continuous models. They are able to explain them using appropriate examples.</li> <li>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>• They know proof strategies and can reproduce them.</li> </ul>		
<i>Skills</i>	<ul style="list-style-type: none"> <li>• 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.</li> <li>• Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul>		
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>• Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>• In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul>		
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>• Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>• Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84		
<b>Credit points</b>	9		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory		

Course L1329: Introduction in Mathematical Modeling	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• The modelling process</li> <li>• deterministic and stochastic models</li> <li>• modelling of dynamic processes</li> <li>• discrete and continuous models</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• C.P. Ortlieb, C. v. Dresky, I. Gasser, S. Günzel : Mathematische Modellierung - Eine Einführung in zwölf Fallstudien, 2. Auflage, Vieweg+Teubner (2012)</li> <li>• Richard Haberman : Mathematical Models: Mechanical Vibrations, Population Dynamics, and Traffic Flow. Classics in Mathematics 21, SIAM (1998).</li> <li>• C. C. Lin und L. A. Segal: Mathematics Applied to Deterministic Problems in the natural Sciences, SIAM (1988)</li> <li>• C. Eck, H. Garcke, P. Knabner: Mathematische Modellierung. Springer (2008)</li> </ul>

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

Module M1078: Geometry				
Courses				
Title			Typ	Hrs/wk CP
Geometry (L1363)			Lecture	4 6
Geometry (L1364)			Recitation Section (small)	2 3
<b>Module Responsible</b>	Prof. Alexander Kreuzer			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Linear Algebra			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i> <ul style="list-style-type: none"> <li>Students 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.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul> <i>Skills</i> <ul style="list-style-type: none"> <li>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.</li> <li>Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul> <b>Personal Competence</b> <i>Social Competence</i> <ul style="list-style-type: none"> <li>Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul> <i>Autonomy</i> <ul style="list-style-type: none"> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>				
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84			
<b>Credit points</b>	9			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 min			
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory			

Course L1363: Geometry	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>Affine and projective planes and spaces</li> <li>Coordinatisation</li> <li>Collineations</li> <li>Fundamental theorems</li> <li>Applications of geometry</li> </ul>
<b>Literature</b>	<ol style="list-style-type: none"> <li>1. M. Berger, <b>Geometry I</b>, Verlag: Springer, 1987</li> <li>2. A. Beutelspacher und U. Rosenbaum, <b>Projektive Geometrie</b>, Verlag Vieweg, 1992</li> <li>3. H. Brauner, <b>Geometrie projektiver Räume I, II</b>, Bl, 1976</li> <li>4. F. Buckenhout (Hrsg.), <b>Handbook of Incidence Geometry</b>, Verlag: Elsevier, 1995</li> <li>5. R. Casse, <b>Projective Geometry: An Introduction</b>, Verlag: Oxford University Press, 2009</li> <li>6. A. Herzer, <b>Geometrie I,II</b>, Skript, Universität Mainz, 1991/92</li> <li>7. A. Holme, <b>Geometry: Our Cultural Heritage</b>, Verlag: Springer, 2002</li> <li>8. D.R. Hughes und F.C. Piper, <b>Projective Planes</b>, Verlag: Springer, 1973</li> <li>9. G.A. Jennings, <b>Modern Geometry with Applications</b>, Verlag: Springer, 1994</li> <li>10. L. Kadison und M.T. Kromann, <b>Projective Geometry and Modern Algebra</b>, Verlag: Birkhäuser, 1996</li> <li>11. H. Karzel und H.-J. Kroll, <b>Geschichte der Geometrie seit Hilbert</b>, Verlag: Wiss. Buchgesellschaft, 1988</li> <li>12. H. Karzel, K. Sörensen und D. Windelberg, <b>Einführung in die Geometrie</b>, Verlag: Vandenhoeck und Rupprecht, 1973</li> <li>13. H. Lenz, <b>Vorlesungen über projektive Geometrie</b>, Akad. Verl.-Ges., 1965</li> <li>14. R. Lingenberg, <b>Grundlagen der Geometrie</b>, Bl, 1978</li> <li>15. E.M. Schröder, <b>Vorlesungen über Geometrie, II</b>, Bl., 1991</li> <li>16. C.J. Scriba und P. Schreiber, <b>5000 Jahre Geometrie</b>, Verlag: Springer, 2001</li> <li>17. J. Ueberberg, <b>Foundations of Incidence Geometry: Projective and Polar Spaces</b>, Verlag: Springer, 2011</li> </ol>

Course L1364: Geometry	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Timo Reis		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Analysis, Higher Analysis, Functional Analysis		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i> <ul style="list-style-type: none"> <li>Students can describe basic concepts in Mathematical Systems Theory such as controllability, stabilization by feedback, observability, observer and controller design and linear-quadratic optimal control. They are able to explain them using appropriate examples.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul> <i>Skills</i> <ul style="list-style-type: none"> <li>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.</li> <li>Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul> <b>Personal Competence</b> <i>Social Competence</i> <ul style="list-style-type: none"> <li>Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul> <i>Autonomy</i> <ul style="list-style-type: none"> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory		

Course L1463: Mathematical Systems Theory	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>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.</p> <p>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.</p> <ul style="list-style-type: none"> <li>Introduction and motivation</li> <li>Controllability</li> <li>Stabilization by feedback</li> <li>Observability</li> <li>Observer and controller design</li> <li>Linear-quadratic optimal control</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>E.D. Sontag, Mathematical Control Theory: Deterministic Finite Dimensional Systems. Second Edition, Springer, New York, 1998</li> <li>T. Kailath, Linear Systems. Prentice-Hall, Englewood Cliffs, 1980</li> <li>H.W. Knobloch, H. Kwakernaak. Lineare Kontrolltheorie. Springer-Verlag, Berlin, 1985</li> <li>K. Zhou, J.C. Doyle, K. Glover. Robust and Optimal Control. Prentice Hall, Upper Saddle River, NJ, 1996</li> </ul>

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

Course L1464: Mathematical Systems Theory	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0941: Combinatorial Structures and Algorithms			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Combinatorial Structures and Algorithms (L1100)	Lecture	3	4
Combinatorial Structures and Algorithms (L1101)	Recitation Section (small)	1	2
<b>Module Responsible</b>	Prof. Anusch Taraz		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Mathematics I + II</li> <li>Discrete Algebraic Structures</li> <li>Graph Theory and Optimization</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>Students can name the basic concepts in Combinatorics and Algorithms. They are able to explain them using appropriate examples.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul>		
<i>Skills</i>	<ul style="list-style-type: none"> <li>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.</li> <li>Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul>		
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul>		
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory Computer Science: Specialisation Computational Mathematics: Elective Compulsory Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory Data Science: Core Qualification: Elective Compulsory Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory		

Course L1100: Combinatorial Structures and Algorithms	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Anusch Taraz, Dr. Dennis Clemens
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>Counting</li> <li>Structural Graph Theory</li> <li>Analysis of Algorithms</li> <li>Extremal Combinatorics</li> <li>Random discrete structures</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>M. Aigner: Diskrete Mathematik, Vieweg, 6. Aufl., 2006</li> <li>J. Matoušek &amp; J. Nešetřil: Diskrete Mathematik - Eine Entdeckungsreise, Springer, 2007</li> <li>A. Steger: Diskrete Strukturen - Band 1: Kombinatorik, Graphentheorie, Algebra, Springer, 2. Aufl. 2007</li> <li>A. Taraz: Diskrete Mathematik, Birkhäuser, 2012.</li> </ul>

Course L1101: Combinatorial Structures and Algorithms	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Anusch Taraz
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Bernd Siebert			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Analysis</li> <li>• Higher Analysis</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i> <ul style="list-style-type: none"> <li>• 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.</li> <li>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>• They know proof strategies and can reproduce them.</li> </ul> <i>Skills</i> <ul style="list-style-type: none"> <li>• 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.</li> <li>• Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul> <b>Personal Competence</b> <i>Social Competence</i> <ul style="list-style-type: none"> <li>• Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>• In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul> <i>Autonomy</i> <ul style="list-style-type: none"> <li>• Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>• Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>				
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84			
<b>Credit points</b>	9			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 min			
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory			

Course L1325: Complex Analysis	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• complex numbers, sequences and series of complex numbers (recapitulation)</li> <li>• real and complex differentiation of complex-valued functions, Wirtinger calculus</li> <li>• holomorphic functions</li> <li>• Cauchy's integral theorem, Cauchy's integral formula, residue theorem</li> <li>• determination of improper (real) integrals via complex methods</li> <li>• conformal maps</li> <li>• homology and homotopy versions of the residue theorem</li> <li>• Maximum principle</li> <li>• Counting of zeros and poles</li> <li>• Proofs of the fundamental theorem of algebra</li> <li>• analytic functions</li> <li>• Fourier series</li> <li>• harmonic functions</li> <li>• The Mittag-Leffler theorem and the Weierstraß factorization theorem</li> <li>• Elliptic functions and integrals</li> <li>• Gamma function</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• W. Fischer, I. Lieb, <b>Einführung in die komplexe Analysis</b>, Verlag: Vieweg+Teubner Verlag; Auflage: 2010</li> <li>• Dietmar A. Salamon, <b>Funktionentheorie</b>, Verlag: Springer Basel; Auflage: 2012</li> <li>• K. Fritzsche, <b>Grundkurs Funktionentheorie</b>, Verlag: Spektrum Akademischer Verlag; Auflage: 2009</li> <li>• E. Freitag, R. Busam, <b>Funktionentheorie 1</b>, Verlag: Springer Berlin Heidelberg, 2002</li> <li>• R. Remmert, G. Schumacher, <b>Funktionentheorie 1</b>, Verlag: Springer Berlin Heidelberg, 2002</li> <li>• L.V. Ahlfors, <b>Complex Analysis</b>, Publisher: McGraw-Hill Science/Engineering/Math; 3 edition (January 1, 1979)</li> <li>• J.B. Conway, <b>Functions of one complex variable</b>, Springer, 1978</li> </ul>

Course L1326: Complex Analysis	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Reinhard Diestel			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Linear Algebra			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>Students 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.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul>			
<i>Skills</i>	<ul style="list-style-type: none"> <li>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.</li> <li>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.</li> </ul>			
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul>			
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84			
<b>Credit points</b>	9			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 min			
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory			

Course L1311: Graph Theory	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Fundamentals of Graph Theory, important invariants and their relations</p> <p>Topics:</p> <ul style="list-style-type: none"> <li>Matchings</li> <li>Connectivity</li> <li>Planar graphs</li> <li>Graph coloring</li> <li>Subgraphs and infinite Graphs</li> <li>Ramsey theory</li> <li>Hamilton cycles</li> <li>Random graphs</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>R.Diestel, <b>Graphentheorie</b> (4. Auflage), Springer 2010</li> <li>R.Diestel, <b>Graph Theory</b> (4th ed'n), GTM 173, Springer 2010/12</li> </ul>

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

Module M1051: Combinatorial Optimization			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Combinatorial Optimization (L1315)	Lecture	4	6
Combinatorial Optimization (L1316)	Recitation Section (small)	2	3
<b>Module Responsible</b>	Prof. Matthias Schacht		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Linear Algebra, Discrete Mathematics		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i> <ul style="list-style-type: none"> <li>Students 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.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul> <i>Skills</i> <ul style="list-style-type: none"> <li>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.</li> <li>Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul> <b>Personal Competence</b> <i>Social Competence</i> <ul style="list-style-type: none"> <li>Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul> <i>Autonomy</i> <ul style="list-style-type: none"> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84		
<b>Credit points</b>	9		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory		

Course L1315: Combinatorial Optimization	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	<p>Introduction to combinatorial optimization</p> <p>Topics:</p> <ul style="list-style-type: none"> <li>• Linear optimization: Polyhedra and LP Duality</li> <li>• Complexity of algorithms</li> <li>• polynomial algorithms for <ul style="list-style-type: none"> <li>◦ minimal spanning trees</li> <li>◦ shortest paths</li> <li>◦ maximum flows and minimum cost flows</li> <li>◦ maximum matching and linear programs</li> <li>◦ polyhedral combinatorics for NP-hard problems (Knapsack, TSP, Clique Partitioning)</li> </ul> </li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• William J. Cook, William H. Cunningham, William R. Pulleyblank, Alexander Schrijver: Combinatorial Optimization. John Wiley &amp; Sons, 1997</li> <li>• Christos H. Papadimitriou, Kenneth Steiglitz: Combinatorial Optimization: Algorithms and Complexity. Dover Publications, 1998</li> <li>• Eugene Lawler: Combinatorial Optimization: Networks and Matroids, Oxford University Press 1995</li> </ul>

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

Module M0720: Matrix Algorithms				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Matrix Algorithms (L0984)		Lecture	2	3
Matrix Algorithms (L0985)		Recitation Section (small)	2	3
<b>Module Responsible</b>	Dr. Jens-Peter Zemke			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Mathematics I - III</li> <li>Numerical Mathematics I/ Numerics</li> <li>Basic knowledge of the programming languages Matlab and C</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> Students are able to</p> <ol style="list-style-type: none"> <li>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;</li> <li>state approaches for the solution of matrix equations (Sylvester, Lyapunov, Riccati).</li> </ol> <p><i>Skills</i> Students are capable to</p> <ol style="list-style-type: none"> <li>implement and assess basic Krylov subspace methods for the solution of eigenvalue problems, linear systems, and model reduction;</li> <li>assess methods used in modern software with respect to computing time, stability, and domain of applicability;</li> <li>adapt the approaches learned to new, unknown types of problem.</li> </ol> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students can</p> <ul style="list-style-type: none"> <li>develop and document joint solutions in small teams;</li> <li>form groups to further develop the ideas and transfer them to other areas of applicability;</li> <li>form a team to develop, build, and advance a software library.</li> </ul> <p><i>Autonomy</i> Students are able to</p> <ul style="list-style-type: none"> <li>correctly assess the time and effort of self-defined work;</li> <li>assess whether the supporting theoretical and practical exercises are better solved individually or in a team;</li> <li>define test problems for testing and expanding the methods;</li> <li>assess their individual progress and, if necessary, to ask questions and seek help.</li> </ul>			
<b>Workload in Hours</b>				
<b>Credit points</b>				
<b>Course achievement</b>				
<b>Examination</b>				
<b>Examination duration and scale</b>				
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory			

Course L0984: Matrix Algorithms	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Jens-Peter Zemke
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>Part A: Krylov Subspace Methods:               <ul style="list-style-type: none"> <li>Basics (derivation, basis, Ritz, OR, MR)</li> <li>Arnoldi-based methods (Arnoldi, GMRes)</li> <li>Lanczos-based methods (Lanczos, CG, BiCG, QMR, SymmLQ, PVL)</li> <li>Sonneveld-based methods (IDR, BiCGStab, TFQMR, IDR(s))</li> </ul> </li> <li>Part B: Matrix Equations:               <ul style="list-style-type: none"> <li>Sylvester Equation</li> <li>Lyapunov Equation</li> <li>Algebraic Riccati Equation</li> </ul> </li> </ul>
<b>Literature</b>	Skript

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

Module M0711: Numerical Mathematics II			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Numerical Mathematics II (L0568)	Lecture	2	3
Numerical Mathematics II (L0569)	Recitation Section (small)	2	3
<b>Module Responsible</b>	Prof. Sabine Le Borne		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Numerical Mathematics I</li> <li>Python knowledge</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i></p> <p>Students are able to</p> <ul style="list-style-type: none"> <li>name advanced numerical methods for interpolation, approximation, integration, eigenvalue problems, eigenvalue problems, nonlinear root finding problems and explain their core ideas,</li> <li>repeat convergence statements for the numerical methods, sketch convergence proofs,</li> <li>explain practical aspects of numerical methods concerning runtime and storage needs</li> <li>explain aspects regarding the practical implementation of numerical methods with respect to computational and storage complexity.</li> </ul> <p><i>Skills</i></p> <p>Students are able to</p> <ul style="list-style-type: none"> <li>implement, apply and compare advanced numerical methods in Python,</li> <li>justify the convergence behaviour of numerical methods with respect to the problem and solution algorithm and to transfer it to related problems,</li> <li>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</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i></p> <p>Students are able to</p> <ul style="list-style-type: none"> <li>work together in heterogeneously composed teams (i.e., teams from different study programs and background knowledge), explain theoretical foundations and support each other with practical aspects regarding the implementation of algorithms.</li> </ul> <p><i>Autonomy</i></p> <p>Students are capable</p> <ul style="list-style-type: none"> <li>to assess whether the supporting theoretical and practical exercises are better solved individually or in a team,</li> <li>to assess their individual progress and, if necessary, to ask questions and seek help.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	25 min		
<b>Assignment for the Following Curricula</b>	Computer Science: Specialisation III. Mathematics: Elective Compulsory Computational Science and Engineering: Specialisation III. Mathematics: Elective Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory		

Course L0568: Numerical Mathematics II	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Sabine Le Borne, Dr. Jens-Peter Zemke
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Error and stability: Notions and estimates</li> <li>2. Rational interpolation and approximation</li> <li>3. Multidimensional interpolation (RBF) and approximation (neural nets)</li> <li>4. Quadrature: Gaussian quadrature, orthogonal polynomials</li> <li>5. Linear systems: Perturbation theory of decompositions, structured matrices</li> <li>6. Eigenvalue problems: LR-, QD-, QR-Algorithmus</li> <li>7. Nonlinear systems of equations: Newton and Quasi-Newton methods, line search (optional)</li> <li>8. Krylov space methods: Arnoldi-, Lanczos methods (optional)</li> </ol>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Skript</li> <li>• Stoer/Bulirsch: Numerische Mathematik 1, Springer</li> <li>• Dahmen, Reusken: Numerik für Ingenieure und Naturwissenschaftler, Springer</li> </ul>

Course L0569: Numerical Mathematics II	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Sabine Le Borne, Dr. Jens-Peter Zemke
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Ulf Kühn			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Linear Algebra			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>Students 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.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul>			
<i>Skills</i>				
<b>Personal Competence</b> <i>Social Competence</i>				
<i>Autonomy</i>				
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84			
<b>Credit points</b>	9			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 min			
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory			

Course L1319: Number Theory	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>Congruences (chinese remainder theorem, Fermat's little problem, application to asymmetric cryptography)</li> <li>Quadratic Remainders (Legendre symbol, quadratic reciprocity)</li> <li>Properties of the ring of integers (units, ideals, classes of ideals)</li> <li>Application to diophantic problems</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>A. Beutelspacher, M.-A. Zschiegner: Diskrete Mathematik für Einsteiger. Vieweg</li> <li>F. Ischebeck: Einladung zur Zahlentheorie. BI</li> <li>J. Kramer: Zahlen für Einsteiger. Vieweg</li> <li>K. Reiss, G. Schmieder: Basiswissen Zahlentheorie. Springer</li> </ul>

Course L1320: Number Theory	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Natalie Neumeyer			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Mathematical Stochastics</li> <li>Mathematical Statistics</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>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.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul>			
<i>Skills</i>	<ul style="list-style-type: none"> <li>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.</li> <li>Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul>			
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul>			
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 108, Study Time in Lecture 42			
<b>Credit points</b>	5			
<b>Course achievement</b>	None			
<b>Examination</b>	Oral exam			
<b>Examination duration and scale</b>	30 min			
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory			

Course L1394: Practical Statistics	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>Nonparametric methods</li> <li>Linear models</li> <li>Multivariate methods</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>P. Dalgaard, Introductory Statistics with R, Springer</li> <li>J. Verzani, Using R for introductory statistics, Chapman &amp; Hall</li> <li>U. Ligges, Programmieren mit R, Springer</li> </ul>

Course L1395: Practical Statistics	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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	<ul style="list-style-type: none"><li>• Linear Algebra</li><li>• Analysis</li><li>• Higher Analysis</li></ul>			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<ul style="list-style-type: none"><li>• Students can name basic concepts in Topology such as metric and topological spaces, separation axioms, subspace, quotient and product topologies, connectivity and compactnes, homotopy, fundamental groups and covering spaces. They are able to explain them using appropriate examples.</li><li>• Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li><li>• They know proof strategies and can reproduce them.</li></ul> <ul style="list-style-type: none"><li>• Students can model problems in Topology with the help of the concepts studied in this course. Moreover, they are capable of solving them by applying established methods.</li><li>• Students are able to discover and verify further logical connections between the concepts studied in the course.</li><li>• For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li></ul> <ul style="list-style-type: none"><li>• Students are able to work together in teams. They are capable to use mathematics as a common language.</li><li>• In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li></ul> <ul style="list-style-type: none"><li>• Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li><li>• Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li></ul>			
<i>Knowledge</i>				
<i>Skills</i>				
Personal Competence				
<i>Social Competence</i>				
<i>Autonomy</i>				
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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• set theoretic topology <ul style="list-style-type: none"> <li>◦ metric and topological spaces</li> <li>◦ separation axiom</li> <li>◦ subspace, quotient and product topologies</li> <li>◦ connectivity</li> <li>◦ compactness</li> </ul> </li> <li>• algebraic topology <ul style="list-style-type: none"> <li>◦ homotopy</li> <li>◦ fundamental groups</li> <li>◦ covering spaces</li> </ul> </li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• J. Munkres, <b>Topology - a first course</b>, Publisher: Prentice Hall College Div (June 1974)</li> <li>• B. v. Querenburg, <b>Mengentheoretische Topologie</b>, Verlag: Springer; Auflage: 3 (4. Oktober 2013)</li> <li>• G. Laures, M. Szymik, <b>Grundkurs Topologie</b>, Verlag: Spektrum Akademischer Verlag; Auflage: 2009</li> <li>• K. Jänich, <b>Topologie</b>, Verlag: Springer; Auflage: 8. Aufl. 2005. 4., korr. Nachdruck 2008</li> <li>• L.A. Steen, J.A. Seebach, Jr., <b>Counterexamples in Topology</b>, Publisher: Dover Publications (September 22, 1995)</li> <li>• O. Viro, O. Ivanov, N. Netsvetaev, V. Kharlamov, <b>Elementary Topology - Problem Textbook</b>, Publisher: American Mathematical Society (September 17, 2008)</li> <li>• A. Hatcher, <b>Algebraic Topology</b>, Verlag: Cambridge University Press (2002)</li> </ul>

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

Module M1556: Set Theory and Mathematical Logic			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Set Theory and Mathematical Logic (L2332)	Lecture	4	6
Set Theory and Mathematical Logic (L2333)	Recitation Section (small)	2	3
<b>Module Responsible</b>	Prof. Benedikt Loewe		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Linear Algebra		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i> <ul style="list-style-type: none"> <li>Students 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.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul> <i>Skills</i> <ul style="list-style-type: none"> <li>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.</li> <li>Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul> <b>Personal Competence</b> <i>Social Competence</i> <ul style="list-style-type: none"> <li>Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul> <i>Autonomy</i> <ul style="list-style-type: none"> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 186, Study Time in Lecture 84		
<b>Credit points</b>	9		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	120 min		
<b>Assignment for the Following Curricula</b>	Technomathematics: Specialisation I. Mathematics: Elective Compulsory		

Course L2332: Set Theory and Mathematical Logic	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>Foundations of mathematical logic and model theory</li> <li>first order predicate logic</li> <li>Gödel's completeness theorem and compactness theorem</li> <li>Löwenheim-Skolem theorems</li> <li>Foundations of set theory &amp; Zermelo-Fraenkel axioms</li> <li>Ordinal numbers and Cardinal numbers</li> <li>Axiom of choice &amp; equivalent formulations</li> </ul>
<b>Literature</b>	Heinz-Dieter Ebbinghaus, Einführung in die Mengenlehre.

Course L2333: Set Theory and Mathematical Logic	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dozenten des Fachbereiches Mathematik der UHH
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Matthias Schulte		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Familiarity with the basic concepts of probability		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i> <ul style="list-style-type: none"> <li>Students can name the basic concepts in probability theory. They are able to explain them using appropriate examples.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul> <i>Skills</i> <ul style="list-style-type: none"> <li>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.</li> <li>Students are able to explore and verify further logical connections between the concepts studied in the course.</li> <li>For a given problem, the students can develop and execute a suitable technique, and are able to critically evaluate the results.</li> </ul> <b>Personal Competence</b> <i>Social Competence</i> <ul style="list-style-type: none"> <li>Students are able to work together (e.g. on their regular home work) and to present their results appropriately (e.g. during exercise class).</li> <li>In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul> <i>Autonomy</i> <ul style="list-style-type: none"> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students can put their knowledge in relation to the contents of other lectures.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Computer Science: Specialisation III. Mathematics: Elective Compulsory Interdisciplinary Mathematics: Specialisation II. Numerical - Modelling Training: Compulsory Technomathematics: Specialisation I. Mathematics: Elective Compulsory		

Course L2643: Probability Theory	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Matthias Schulte
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Measure and probability spaces</li> <li>• Integration and expectation</li> <li>• Types of stochastic convergence</li> <li>• Law of large numbers</li> <li>• Central limit theorem</li> <li>• Radon-Nikodym theorem</li> <li>• Conditional expectation</li> <li>• Martingales</li> <li>• Markov chains</li> <li>• Poisson processes</li> </ul>
<b>Literature</b>	<p>H. Bauer, Probability theory and elements of measure theory, second edition, Academic Press, 1981.</p> <p>A. Klenke, Probability Theory: A Comprehensive Course, second edition, Springer, 2014.</p> <p>G. F. Lawler, Introduction to Stochastic Processes, second edition, Chapman &amp; Hall/CRC, 2006.</p> <p>A. N. Shiryaev, Probability, second edition, Springer, 1996.</p>

Course L2644: Probability Theory	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Matthias Schulte
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Sibylle Schupp		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Automata theory and formal languages</li> <li>Procedural programming or Functional programming</li> <li>Object-oriented programming, algorithms, and data structures</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	Students 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.		
<i>Skills</i>	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.		
<b>Personal Competence</b>			
<i>Social Competence</i>	Students practice peer programming. They explain problems and solutions to their peer. They communicate in English.		
<i>Autonomy</i>	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.		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>
	Yes	15 %	Exercises
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90 min		
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Elective Compulsory Computer Science: Core Qualification: Compulsory General Engineering Science (English program, 7 semester): Specialisation Computer Science: Elective Compulsory Computational Science and Engineering: Specialisation I. Computer Science: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory		

#### Course L0627: Software Engineering

<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Sibylle Schupp
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>Software Life Cycle Models (Waterfall, V-Model, Evolutionary Models, Incremental Models, Iterative Models, Agile Processes)</li> <li>Requirements (Elicitation Techniques, UML Use Case Diagrams, Functional and Non-Functional Requirements)</li> <li>Specification (Finite State Machines, Extended FSMs, Petri Nets, Behavioral UML Diagrams, Data Modeling)</li> <li>Design (Design Concepts, Modules, (Agile) Design Principles)</li> <li>Object-Oriented Analysis and Design (Object Identification, UML Interaction Diagrams, UML Class Diagrams, Architectural Patterns)</li> <li>Testing (Blackbox Testing, Whitebox Testing, Control-Flow Testing, Data-Flow Testing, Testing in the Large)</li> <li>Maintenance and Evolution (Regression Testing, Reverse Engineering, Reengineering)</li> <li>Project Management (Blackbox Estimation Techniques, Whitebox Estimation Techniques, Project Plans, Gantt Charts, PERT Charts)</li> </ul>
<b>Literature</b>	Kassem A. Saleh, Software Engineering, J. Ross Publishing 2009.

Course L0628: Software Engineering	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Sibylle Schupp
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0624: Automata Theory and Formal Languages			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Automata Theory and Formal Languages (L0332)	Lecture	2	4
Automata Theory and Formal Languages (L0507)	Recitation Section (small)	2	2
<b>Module Responsible</b>	Prof. Tobias Knopp		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Participating students should be able to <ul style="list-style-type: none"> <li>- specify algorithms for simple data structures (such as, e.g., arrays) to solve computational problems</li> <li>- apply propositional logic and predicate logic for specifying and understanding mathematical proofs</li> <li>- apply the knowledge and skills taught in the module Discrete Algebraic Structures</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	Students can explain 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.		
<i>Skills</i>	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.		
<b>Personal Competence</b> <i>Social Competence</i> <i>Autonomy</i>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90 min		
<b>Assignment for the Following Curricula</b>	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 General Engineering Science (English program, 7 semester): Specialisation Mechatronics: Elective Compulsory Computational Science and Engineering: Core Qualification: Compulsory Orientation Studies: Core Qualification: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory		

Course L0332: Automata Theory and Formal Languages	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Tobias Knopp
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Propositional logic, Boolean algebra, propositional resolution, SAT-2KNF</li> <li>2. Predicate logic, unification, predicate logic resolution</li> <li>3. Temporal Logics (LTL, CTL)</li> <li>4. Deterministic finite automata, definition and construction</li> <li>5. Regular languages, closure properties, word problem, string matching</li> <li>6. Nondeterministic automata: <ul style="list-style-type: none"> <li>Rabin-Scott transformation of nondeterministic into deterministic automata</li> </ul> </li> <li>7. Epsilon automata, minimization of automata, elimination of e-edges, uniqueness of the minimal automaton (modulo renaming of states)</li> <li>8. Myhill-Nerode Theorem: <ul style="list-style-type: none"> <li>Correctness of the minimization procedure, equivalence classes of strings induced by automata</li> </ul> </li> <li>9. Pumping Lemma for regular languages: <ul style="list-style-type: none"> <li>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</li> </ul> </li> <li>10. Regular expressions vs. finite automata: <ul style="list-style-type: none"> <li>Equivalence of formalisms, systematic transformation of representations, reductions</li> </ul> </li> <li>11. Pushdown automata and context-free grammars: <ul style="list-style-type: none"> <li>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)</li> </ul> </li> <li>12. Chomsky normal form</li> <li>13. CYK algorithm for deciding the word problem for context-free grammars</li> <li>14. Deterministic pushdown automata</li> <li>15. Deterministic vs. nondeterministic pushdown automata: <ul style="list-style-type: none"> <li>Application for parsing, LL(k) or LR(k) grammars and parsers vs. deterministic pushdown automata, compiler compiler</li> </ul> </li> <li>16. Regular grammars</li> <li>17. Outlook: Turing machines and linear bounded automata vs general and context-sensitive grammars</li> <li>18. Chomsky hierarchy</li> <li>19. Mealy- and Moore automata: <ul style="list-style-type: none"> <li>Automata with output (w/o accepting states), infinite state sequences, automata networks</li> </ul> </li> <li>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)</li> <li>21. LTL safety conditions and model checking with Büchi automata, relationships between automata and logic</li> <li>22. Fixed points, propositional mu-calculus</li> <li>23. Characterization of regular languages by monadic second-order logic (MSO)</li> </ol>
<b>Literature</b>	<ol style="list-style-type: none"> <li>1. Logik für Informatiker Uwe Schöning, Spektrum, 5. Aufl.</li> <li>2. Logik für Informatiker Martin Kreuzer, Stefan Kühling, Pearson Studium, 2006</li> <li>3. Grundkurs Theoretische Informatik, Gottfried Vossen, Kurt-Ulrich Witt, Vieweg-Verlag, 2010.</li> <li>4. Principles of Model Checking, Christel Baier, Joost-Pieter Katoen, The MIT Press, 2007</li> </ol>

Course L0507: Automata Theory and Formal Languages	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Tobias Knopp
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Tobias Knopp			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	procedural programming, linear algebra			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> The students</p> <ul style="list-style-type: none"> <li>can efficiently solve scientific problems in a modern programming language.</li> <li>are familiar with the concept of reproducible science.</li> <li>can handle multidimensional arrays, sparse arrays, data frames and missing data. They know the advantages and disadvantages of specific data structures.</li> <li>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.</li> </ul> <p><i>Skills</i> Students are able</p> <ul style="list-style-type: none"> <li>to translate complex problems from a mathematical formulation into a suitable program.</li> <li>to divide a complex problem into subproblems which can be implemented modularly.</li> <li>to identify numerical standard problems and to use suitable standard algorithms which are available in libraries.</li> <li>to write maintainable program code, the correctness of which is verified by suitable tests.</li> <li>to measure the runtime of programs, to identify bottlenecks and to apply suitable acceleration techniques.</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> 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.</p> <p><i>Autonomy</i> Students are able to independently investigate a complex problem and assess which competencies are required to solve it.</p>			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 min			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Tobias Knopp
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>Elementary Data Types and the Relationship to Mathematics</li> <li>Scientific data types: Multidimensional Arrays, sparse Arrays, Data Frames, Missing Data</li> <li>Multiple Dispatch as an Efficient Paradigm for Scientific Programming</li> <li>Literate Programming</li> <li>Profiling and benchmarks</li> <li>Acceleration techniques: caching, multi-threading, SIMD, GPGPU</li> <li>Scientific data formats: CSV, TOML, HDF5, and selected examples</li> <li>Data visualization</li> <li>Standard numerical techniques and efficient program libraries (BLAS, LAPACK, FFTW, ...)</li> <li>Tests, code management, documentation</li> <li>Reproducible science</li> </ul>
<b>Literature</b>	Ben Lauwens, Allen Downey: Think Julia: How to Think Like a Computer Scientist

Course L2406: Scientific Programming	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Tobias Knopp
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Heiko Falk			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge in electrical engineering			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p>This module deals with the foundations of the functionality of computing systems. It covers the layers from the assembly-level programming down to gates. The module includes the following topics:</p> <ul style="list-style-type: none"> <li>• Introduction</li> <li>• Combinational logic: Gates, Boolean algebra, Boolean functions, hardware synthesis, combinational networks</li> <li>• Sequential logic: Flip-flops, automata, systematic hardware design</li> <li>• Technological foundations</li> <li>• Computer arithmetic: Integer addition, subtraction, multiplication and division</li> <li>• Basics of computer architecture: Programming models, MIPS single-cycle architecture, pipelining</li> <li>• Memories: Memory hierarchies, SRAM, DRAM, caches</li> <li>• Input/output: I/O from the perspective of the CPU, principles of passing data, point-to-point connections, busses</li> </ul> <p><i>Skills</i> The students perceive computer systems from the architect's perspective, i.e., they identify the internal structure and the physical composition of computer systems. The students can analyze, how highly specific and individual computers can be built based on a collection of few and simple components. They are able to distinguish between and to explain the different abstraction layers of today's computing systems - from gates and circuits up to complete processors.</p> <p>After successful completion of the module, the students are able to judge the interdependencies between a physical computer system and the software executed on it. In particular, they shall understand the consequences that the execution of software has on the hardware-centric abstraction layers from the assembly language down to gates. This way, they will be enabled to evaluate the impact that these low abstraction levels have on an entire system's performance and to propose feasible options.</p>			
<b>Personal Competence</b>				
<i>Social Competence</i>				
<i>Autonomy</i>				
<b>Workload in Hours</b>				
<b>Credit points</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	10 %	Exercices	
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 minutes, contents of course and labs			
<b>Assignment for the Following Curricula</b>	<p>General Engineering Science (German program, 7 semester): Specialisation Computer Science: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Civil Engineering: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Green Technologies, Focus Renewable Energy: Elective Compulsory</p> <p>Computer Science: Core Qualification: Compulsory</p> <p>Data Science: Core Qualification: Elective Compulsory</p> <p>Electrical Engineering: Core Qualification: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Civil Engineering: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems</p>			

	Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory Computational Science and Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory
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Course L0321: Computer Engineering	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Heiko Falk
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction</li> <li>• Combinational Logic</li> <li>• Sequential Logic</li> <li>• Technological Foundations</li> <li>• Representations of Numbers, Computer Arithmetics</li> <li>• Foundations of Computer Architecture</li> <li>• Memories</li> <li>• Input/Output</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• A. Clements. The Principles of Computer Hardware. 3. Auflage, Oxford University Press, 2000.</li> <li>• A. Tanenbaum, J. Goodman. Computerarchitektur. Pearson, 2001.</li> <li>• D. Patterson, J. Hennessy. Rechnerorganisation und -entwurf. Elsevier, 2005.</li> </ul>

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

Module M0834: Computernetworks and Internet Security				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Computer Networks and Internet Security (L1098)		Lecture	3	5
Computer Networks and Internet Security (L1099)		Recitation Section (small)	1	1
<b>Module Responsible</b>	Prof. Andreas Timm-Giel			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basics of Computer Science			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p>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.</p> <p>Students are able to analyse common Internet protocols and evaluate the use of them in different domains.</p> <p>Students can select relevant parts out of high amount of professional knowledge and can independently learn and understand it.</p>			
<i>Knowledge</i>				
<i>Skills</i>				
<b>Personal Competence</b>				
<i>Social Competence</i>				
<i>Autonomy</i>				
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 min			
<b>Assignment for the Following Curricula</b>	<p>General Engineering Science (German program, 7 semester): Specialisation Computer Science: Elective Compulsory</p> <p>Computer Science: Core Qualification: Compulsory</p> <p>Data Science: Core Qualification: Elective Compulsory</p> <p>Electrical Engineering: Core Qualification: Elective Compulsory</p> <p>Engineering Science: Specialisation Mechatronics: Elective Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Computer Science: Elective Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Mechatronics: Elective Compulsory</p> <p>Computational Science and Engineering: Core Qualification: Compulsory</p> <p>Technomathematics: Specialisation II. Informatics: Elective Compulsory</p>			

  

Course L1098: Computer Networks and Internet Security	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	5
<b>Workload in Hours</b>	Independent Study Time 108, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Andreas Timm-Giel, Prof. Dieter Gollmann, Dr.-Ing. Koojana Kuladinithi
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<p>In this class an introduction to computer networks with focus on the Internet and its security is given. Basic functionality of complex protocols are introduced. Students learn to understand these and identify common principles. In the exercises these basic principles and an introduction to performance modelling are addressed using computing tasks and (virtual) labs.</p> <p>In the second part of the lecture an introduction to Internet security is given.</p> <p>This class comprises:</p> <ul style="list-style-type: none"> <li>• Application layer protocols (HTTP, FTP, DNS)</li> <li>• Transport layer protocols (TCP, UDP)</li> <li>• Network Layer (Internet Protocol, routing in the Internet)</li> <li>• Data link layer with media access at the example of Ethernet</li> <li>• Multimedia applications in the Internet</li> <li>• Network management</li> <li>• Internet security: IPSec</li> <li>• Internet security: Firewalls</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Kurose, Ross, Computer Networking - A Top-Down Approach, 6th Edition, Addison-Wesley</li> <li>• Kurose, Ross, Computernetzwerke - Der Top-Down-Ansatz, Pearson Studium; Auflage: 6. Auflage</li> <li>• W. Stallings: Cryptography and Network Security: Principles and Practice, 6th edition</li> </ul> <p>Further literature is announced at the beginning of the lecture.</p>

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

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
<b>Module Responsible</b>	Prof. Sibylle Schupp			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Discrete mathematics at high-school level			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students practice peer programming with varying peers. They explain problems and solutions to their peer. They defend their programs orally. They communicate in English.</p> <p><i>Autonomy</i> 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.</p>			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	15 %	Exercices	
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 min			
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Elective Compulsory Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Elective Compulsory Engineering Science: Specialisation Mechatronics: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Computer Science: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechatronics: Elective Compulsory Computational Science and Engineering: Specialisation I. Computer Science: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory			

Course L0624: Functional Programming	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Sibylle Schupp
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Functions, Currying, Recursive Functions, Polymorphic Functions, Higher-Order Functions</li> <li>• Conditional Expressions, Guarded Expressions, Pattern Matching, Lambda Expressions</li> <li>• Types (simple, composite), Type Classes, Recursive Types, Algebraic Data Type</li> <li>• Type Constructors: Tuples, Lists, Trees, Associative Lists (Dictionaries, Maps)</li> <li>• Modules</li> <li>• Interactive Programming</li> <li>• Lazy Evaluation, Call-by-Value, Strictness</li> <li>• Design Recipes</li> <li>• Testing (axiom-based, invariant-based, against reference implementation)</li> <li>• Reasoning about Programs (equation-based, inductive)</li> <li>• Idioms of Functional Programming</li> <li>• Haskell Syntax and Semantics</li> </ul>
<b>Literature</b>	Graham Hutton, Programming in Haskell, Cambridge University Press 2007.

Course L0625: Functional Programming	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Sibylle Schupp
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Functions, Currying, Recursive Functions, Polymorphic Functions, Higher-Order Functions</li> <li>• Conditional Expressions, Guarded Expressions, Pattern Matching, Lambda Expressions</li> <li>• Types (simple, composite), Type Classes, Recursive Types, Algebraic Data Type</li> <li>• Type Constructors: Tuples, Lists, Trees, Associative Lists (Dictionaries, Maps)</li> <li>• Modules</li> <li>• Interactive Programming</li> <li>• Lazy Evaluation, Call-by-Value, Strictness</li> <li>• Design Recipes</li> <li>• Testing (axiom-based, invariant-based, against reference implementation)</li> <li>• Reasoning about Programs (equation-based, inductive)</li> <li>• Idioms of Functional Programming</li> <li>• Haskell Syntax and Semantics</li> </ul>
<b>Literature</b>	Graham Hutton, Programming in Haskell, Cambridge University Press 2007.

Course L0626: Functional Programming	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Sibylle Schupp
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Functions, Currying, Recursive Functions, Polymorphic Functions, Higher-Order Functions</li> <li>• Conditional Expressions, Guarded Expressions, Pattern Matching, Lambda Expressions</li> <li>• Types (simple, composite), Type Classes, Recursive Types, Algebraic Data Type</li> <li>• Type Constructors: Tuples, Lists, Trees, Associative Lists (Dictionaries, Maps)</li> <li>• Modules</li> <li>• Interactive Programming</li> <li>• Lazy Evaluation, Call-by-Value, Strictness</li> <li>• Design Recipes</li> <li>• Testing (axiom-based, invariant-based, against reference implementation)</li> <li>• Reasoning about Programs (equation-based, inductive)</li> <li>• Idioms of Functional Programming</li> <li>• Haskell Syntax and Semantics</li> </ul>
<b>Literature</b>	Graham Hutton, Programming in Haskell, Cambridge University Press 2007.

Module M1423: Algorithms and Data Structures			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Algorithms and Data Structures (L2046)	Lecture	4	4
Algorithms and Data Structures (L2047)	Recitation Section (small)	1	2
<b>Module Responsible</b>	Prof. Matthias Mnich		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Discrete Algebraic Structures</li> <li>Mathematics I</li> <li>Mathematics II</li> <li>Procedural Programming</li> <li>Objectoriented Programming</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>Students can name the basic concepts in algorithm design, algorithm analysis and problem reductions. They are able to explain them using appropriate examples.</li> <li>Students can discuss logical connections between these concepts. They are capable of illustrating these connections with the help of examples.</li> <li>They know proof strategies and can reproduce them.</li> </ul>		
<i>Skills</i>	<ul style="list-style-type: none"> <li>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.</li> <li>Students are able to discover and verify further logical connections between the concepts studied in the course.</li> <li>For a given problem, the students can develop and execute a suitable approach, and are able to critically evaluate the results.</li> </ul>		
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>Students are able to work together in teams. They are capable to use mathematics as a common language.</li> <li>In doing so, they can communicate new concepts according to the needs of their cooperating partners. Moreover, they can design examples to check and deepen the understanding of their peers.</li> </ul>		
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>Students are capable of checking their understanding of complex concepts on their own. They can specify open questions precisely and know where to get help in solving them.</li> <li>Students have developed sufficient persistence to be able to work for longer periods in a goal-oriented manner on hard problems.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	60 min		
<b>Assignment for the Following Curricula</b>	Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Compulsory Computational Science and 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 64, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Matthias Mnich
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Insertion sort</li> <li>• Register machines</li> <li>• Asymptotic analysis, Landau notation</li> <li>• Polynomial-time algorithms and NP-completeness</li> <li>• Divide-and-conquer, merge sort</li> <li>• Strassen algorithm</li> <li>• Greedy algorithm</li> <li>• Dynamic programming</li> <li>• Quick sort</li> <li>• AVL-trees, B-trees</li> <li>• Hashing</li> <li>• Depth first search, breadth first search</li> <li>• Shortest paths</li> <li>• Flow problems, Ford-Fulkerson algorithm</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• T. Cormen, Ch. Leiserson, R. Rivest, C. Stein: Introduction to Algorithms. MIT Press, 2013</li> <li>• S. Skiena: The Algorithm Design Manual. Springer, 2008</li> <li>• J. M. Kleinberg and É. Tardos. Algorithm Design. Addison-Wesley, 2005.</li> </ul>

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

Module M0625: Databases					
Courses					
Title		Typ	Hrs/wk	CP	
Databases (L0337)		Lecture	3	5	
Databases (L1150)		Project-/problem-based Learning	1	1	
Module Responsible	Prof. Stefan Schulte				
Admission Requirements	None				
Recommended Previous Knowledge	Students should have basic knowledge in the following areas: <ul style="list-style-type: none"><li>• Discrete Algebraic Structures</li><li>• Procedural Programming</li><li>• Automata Theory and Formal Languages</li><li>• Programming Paradigms</li></ul>				
Educational Objectives	After taking part successfully, students have reached the following learning results				
Professional Competence					
Knowledge					After successful completion of the course, students know: <ul style="list-style-type: none"><li>• Design instruments for relational databases</li><li>• The relational model</li><li>• Relational query languages, especially SQL</li><li>• Requirements on data integrity</li><li>• Possibilities for query optimization</li><li>• Aspects of transaction handling, fault handling and concurrency/synchronization in database systems</li><li>• Specific attributes and differences of object-oriented and object-relational databases</li><li>• Paradigms and concepts of current technologies for data modelling and database systems</li></ul>
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 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 Computer and Software Engineering: Elective Compulsory Computer Science: Specialisation I. Computer and Software Engineering: Elective Compulsory Data Science: Core Qualification: Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory				

Course L0337: Databases	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	5
<b>Workload in Hours</b>	Independent Study Time 108, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Stefan Schulte
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction to database systems</li> <li>• Database design, especially entity-relationship</li> <li>• The relational model</li> <li>• Relational query languages</li> <li>• Data integrity and temporal data</li> <li>• Query processing</li> <li>• Transaction management</li> <li>• Fault tolerance</li> <li>• Concurrency control</li> <li>• Object-oriented databases</li> <li>• Object-relational databases</li> <li>• XML data modelling</li> <li>• NoSQL databases</li> <li>• Big data (Overview)</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• R. Ramakrishnan, J. Gehrke, Database Management Systems, McGraw Hill, 2003</li> <li>• A. Kemper, A. Eickler, Datenbanksysteme, 10. Auflage, De Gruyter, Oldenbourg, 2015</li> </ul>

Course L1150: Databases	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Stefan Schulte
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0668: Algebra and Control			
<b>Courses</b>			
<b>Title</b>	<b>Type</b>	<b>Hrs/wk</b>	<b>CP</b>
Algebra and Control (L0428)	Lecture	2	4
Algebra and Control (L0429)	Recitation Section (small)	2	2
<b>Module Responsible</b>	Dr. Prashant Batra		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basics of Real Analysis and Linear Algebra of Vector Spaces and either of: Introduction to Control Theory or: Discrete Mathematics		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>  <i>Knowledge</i>          <i>Skills</i>	Students can  <ul style="list-style-type: none"> <li>Describe input-output systems polynomially</li> <li>Explain factorization approaches to transfer functions</li> <li>Name stabilization conditions for systems in coprime stable factorization.</li> </ul> Students are able to  <ul style="list-style-type: none"> <li>Undertake a synthesis of stable control loops</li> <li>Apply suitable methods of analysis and synthesis to describe all stable control loops</li> <li>Ensure the fulfillment of specified performance measurements.</li> </ul>		
<b>Personal Competence</b>  <i>Social Competence</i>  <i>Autonomy</i>	After completing the module, students are able to solve subject-related tasks and to present the results.  Students are provided with tasks which are exam-related so that they can examine their learning progress and reflect on it.		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	Computer Science: Specialisation Computational Mathematics: Elective Compulsory Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory		

Course L0428: Algebra and Control	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Prashant Batra
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- Algebraic control methods, polynomial and fractional approach</li> <li>- Single input - single output (SISO) control systems synthesis by algebraic methods,</li> <li>- Simultaneous stabilization</li> <li>- Parametrization of all stabilizing controllers</li> <li>- Selected methods of pole assignment.</li> <li>- Filtering and sensitivity minimization</li> <li>- Polynomial matrices, left and right polynomial fractions.</li> <li>- Euclidean algorithm, diophantine equations over rings</li> <li>- Smith-McMillan normal form</li> <li>- Multiple input - multiple output control system synthesis by polynomial methods, condition of stability.</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Vidyasagar, M.: Control system synthesis: a factorization approach. The MIT Press, Cambridge/Mass. - London, 1985.</li> <li>• Vardulakis, A.I.G.: Linear multivariable control. Algebraic analysis and synthesis methods, John Wiley &amp; Sons, Chichester, UK, 1991.</li> <li>• Chen, Chi-Tsong: Analog and digital control system design. Transfer-function, state-space, and algebraic methods. Oxford Univ. Press, 1995.</li> <li>• Kučera, V.: Analysis and Design of Discrete Linear Control Systems. Praha: Academia, 1991.</li> </ul>

Course L0429: Algebra and Control	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Prashant Batra
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Sibylle Schupp			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Practical programming experience</li> <li>• Automata theory and formal languages</li> <li>• Functional programming or procedural programming</li> <li>• Object-oriented programming, algorithms, and data structures</li> <li>• Basic knowledge of software engineering</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> 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.</p> <p><i>Autonomy</i> 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.</p>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Subject theoretical and practical work			
<b>Examination duration and scale</b>	Software (Compiler)			
<b>Assignment for the Following Curricula</b>	Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory Computer Science: Specialisation I. Computer and Software Engineering: Elective Compulsory Computational Science and Engineering: Specialisation I. Computer Science: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory			

Course L0703: Compiler Construction	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Sibylle Schupp
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Lexical and syntactic analysis</li> <li>• Semantic analysis</li> <li>• High-level optimization</li> <li>• Intermediate languages and code generation</li> <li>• Compilation pipeline</li> </ul>
<b>Literature</b>	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	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Sibylle Schupp
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0562: Computability and Complexity Theory				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Computability and Complexity Theory (L0166)		Lecture	2	3
Computability and Complexity Theory (L0167)		Recitation Section (small)	2	3
<b>Module Responsible</b>	Prof. Karl-Heinz Zimmermann			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Discrete Algebraic Structures, Automata Theory, Logic, and Formal Language Theory.			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	The students know the important machine models of computability, the class of partial recursive functions, universal computability, Gödel numbering of computations, the theorems of Kleene, Rice, and Rice-Shapiro, the concept of decidable and undecidable sets, the word problems for semi-Thue systems, Thue systems, semi-groups, and Post correspondence systems, Hilbert's 10-th problem, and the basic concepts of complexity theory.			
<i>Skills</i>	Students are able to investigate the computability of sets and functions and to analyze the complexity of computable functions.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students are able to solve specific problems alone or in a group and to present the results accordingly.			
<i>Autonomy</i>	Students are able to acquire new knowledge from newer literature and to associate the acquired knowledge with other classes.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	60 min			
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Computer Science: Elective Compulsory Computer Science: Core Qualification: Compulsory Data Science: Core Qualification: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Computer Science: Elective Compulsory Computational Science and Engineering: Specialisation I. Computer Science: Elective Compulsory Technomathematics: Specialisation II. Informatics: Elective Compulsory			

Course L0166: Computability and Complexity Theory	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Karl-Heinz Zimmermann
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	

Course L0167: Computability and Complexity Theory	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Karl-Heinz Zimmermann
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	

### Specialization III. Engineering Science

#### Module M0536: Fundamentals of Fluid Mechanics

##### Courses

Title	Type	Hrs/wk	CP
Fundamentals of Fluid Mechanics (L0091)	Lecture	2	4
Fluid Mechanics for Process Engineering (L0092)	Recitation Section (large)	2	2
Module Responsible	Prof. Michael Schlüter		
Admission Requirements	None		
Recommended Previous Knowledge	<ul style="list-style-type: none"><li>Mathematics I+II+III</li><li>Technical Mechanics I+II</li><li>Technical Thermodynamics I+II</li><li>Working with force balances</li><li>Simplification and solving of partial differential equations</li><li>Integration</li></ul>		
Educational Objectives	After taking part successfully, students have reached the following learning results		
Professional Competence	<div>Knowledge</div> <p>Students are able to:</p> <ul style="list-style-type: none"><li>explain the difference between different types of flow</li><li>give an overview for different applications of the Reynolds Transport-Theorem in process engineering</li><li>explain simplifications of the Continuity- and Navier-Stokes-Equation by using physical boundary conditions</li></ul> <div>Skills</div> <p>The students are able to</p> <ul style="list-style-type: none"><li>describe and model incompressible flows mathematically</li><li>reduce the governing equations of fluid mechanics by simplifications to archive quantitative solutions e.g. by integration</li><li>notice the dependency between theory and technical applications</li><li>use the learned basics for fluid dynamical applications in fields of process engineering</li></ul> <div>Personal Competence</div> <div>Social Competence</div> <p>The students</p> <ul style="list-style-type: none"><li>are capable to gather information from subject related, professional publications and relate that information to the context of the lecture and</li><li>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)</li><li>are able to work out solutions for exercises by themselves, to discuss the solutions orally and to present the results.</li></ul> <div>Autonomy</div> <p>The students are able to</p> <ul style="list-style-type: none"><li>search further literature for each topic and to expand their knowledge with this literature,</li><li>work on their exercises by their own and to evaluate their actual knowledge with the feedback.</li></ul>		
Workload in Hours			
Credit points			
Course achievement			
Examination			
Examination duration and scale			
Assignment for the Following Curricula	General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Energy and Environmental Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Michael Schlüter
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• fluid properties</li> <li>• hydrostatic</li> <li>• overall balances - theory of streamline</li> <li>• overall balances- conservation equations</li> <li>• differential balances - Navier Stokes equations</li> <li>• irrotational flows - Potenzialströmungen</li> <li>• flow around bodies - theory of physical similarity</li> <li>• turbulent flows</li> <li>• compressible flows</li> </ul>
<b>Literature</b>	<ol style="list-style-type: none"> <li>1. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.</li> <li>2. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.</li> <li>3. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley &amp; Sons, 1994</li> <li>4. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006</li> <li>5. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008</li> <li>6. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007</li> <li>7. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2009</li> <li>8. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007</li> <li>9. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008</li> <li>10. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006</li> <li>11. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.</li> <li>12. White, F.: Fluid Mechanics, Mcgraw-Hill, ISBN-10: 0071311211, ISBN-13: 978-0071311212, 2011</li> </ol>

Course L0092: Fluid Mechanics for Process Engineering	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Michael Schlüter
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	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.
<b>Literature</b>	<ol style="list-style-type: none"> <li>1. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.</li> <li>2. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.</li> <li>3. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley &amp; Sons, 1994</li> <li>4. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006</li> <li>5. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008</li> <li>6. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007</li> <li>7. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2009</li> <li>8. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007</li> <li>9. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008</li> <li>10. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006</li> <li>11. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.</li> <li>12. White, F.: Fluid Mechanics, Mcgraw-Hill, ISBN-10: 0071311211, ISBN-13: 978-0071311212, 2011</li> </ol>

Module M0634: Introduction into Medical Technology and Systems				
<b>Courses</b>				
<b>Title</b>	<b>Typ</b>		<b>Hrs/wk</b>	<b>CP</b>
Introduction into Medical Technology and Systems (L0342)	Lecture		2	3
Introduction into Medical Technology and Systems (L0343)	Project Seminar		2	2
Introduction into Medical Technology and Systems (L1876)	Recitation Section (large)		1	1
<b>Module Responsible</b>	Prof. Alexander Schläefer			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	principles of math (algebra, analysis/calculus) principles of stochastics principles of programming, R/Matlab			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	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.  The students are able to evaluate systems and medical devices in the context of clinical applications.  The students describe a problem in medical technology as a project, and define tasks that are solved in a joint effort.  The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.			
<i>Knowledge</i>				
<i>Skills</i>				
<b>Personal Competence</b>				
<i>Social Competence</i>	The students describe a problem in medical technology as a project, and define tasks that are solved in a joint effort.			
<i>Autonomy</i>	The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	10 %	Written elaboration	
	Yes	10 %	Presentation	
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 minutes			
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory Computer Science: Specialisation II. Mathematics and Engineering Science: 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 Computational Science and 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Alexander Schläefer
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	- 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.
<b>Literature</b>	Wird in der Veranstaltung bekannt gegeben.

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

Course L1876: Introduction into Medical Technology and Systems	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Alexander Schlaefer
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- imaging systems</li> <li>- computer aided surgery</li> <li>- medical sensor systems</li> <li>- medical information systems</li> <li>- regulatory affairs</li> <li>- standard in medical technology</li> </ul> <p>The students will work in groups to apply the methods introduced during the lecture using problem based learning.</p>
<b>Literature</b>	Wird in der Veranstaltung bekannt gegeben.

Module M0680: Fluid Dynamics				
Courses				
Title			Typ	Hrs/wk CP
Fluid Mechanics (L0454)			Lecture	3 4
Fluid Mechanics (L0455)			Recitation Section (large)	2 2
<b>Module Responsible</b>	Prof. Thomas Rung			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Sound knowledge of engineering mathematics, engineering mechanics and thermodynamics.			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	Students will have the required sound knowledge to explain the general principles of fluid engineering and physics of fluids. Students can scientifically outline the rationale of flow physics using mathematical models and are familiar with methods for the performance analysis and the prediction of fluid engineering devices.			
<i>Skills</i>	Students are able to apply fluid-engineering principles and flow-physics models for the analysis of technical systems. The lecture enables the student to carry out all necessary theoretical calculations for the fluid dynamic design of engineering devices on a scientific level.			
<b>Personal Competence</b>				
<i>Social Competence</i>	The students are able to discuss problems and jointly develop solution strategies.			
<i>Autonomy</i>	The students are able to develop solution strategies for complex problems self-consistent and critically analyse results.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	180 min			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Thomas Rung
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• continuum physics definition of fluids, difference to solids/structures and material properties of fluids</li> <li>• dimensional analysis and similitude</li> <li>• fluid forces and fluid statics</li> <li>• transport and conservation of mass, momentum &amp; energy</li> <li>• fluid kinematics</li> <li>• technically relevant flow models for incompressible fluids <ul style="list-style-type: none"> <li>◦ control volume &amp; stream tube analysis</li> <li>◦ vortical flow models</li> <li>◦ potential flows</li> <li>◦ boundary layer flows</li> <li>◦ different types of conservation equations and their realm (Navier-Stokes/Euler/Bernoulli equations)</li> <li>◦ analytical solutions for Navier-Stokes systems</li> </ul> </li> <li>• Analysis of internal flows (channels, pipes, open channels) and external flows, fundamentals of wing aerodynamics</li> <li>• turbulent flows</li> <li>• fundamentals of gas dynamics (1D compressible flows)</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• the course primarily refers to / das Modul stützt sich bevorzugt auf : Munson, B.R.; Rothmayer, A.P.; Okiishi, T.H.; Huebsch, W.W.: <b>Fundamentals of Fluid Mechanics</b>, John Wiley &amp; Sons.</li> <li>• Spurk, J.; Aksel, N.: Strömungslehre, Springer.</li> <li>• Schade, H.; Kunz, E., Kameier, F.; Paschereit, C.O.: Strömungslehre, De Gruyter.</li> <li>• Herwig, H.: Strömungsmechanik, Springer.</li> <li>• Herwig, H.: Strömungsmechanik von A-Z, Vieweg.</li> </ul>

Course L0455: Fluid Mechanics	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Thomas Rung
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Johannes Gescher			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	none			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i>	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			
	-			
<i>Skills</i>				
<b>Personal Competence</b> <i>Social Competence</i>	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			
<i>Autonomy</i>	The students are able to present the results of their subtasks in a written report			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 min			
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Paul Bubenheim
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. The molecular logic of Life</li> <li>2. Biomolecules: <ol style="list-style-type: none"> <li>1. Amino acids, peptides, proteins</li> <li>2. Carbohydrates</li> <li>3. Lipids</li> </ol> </li> <li>3. Protein functions, Enzymes: <ol style="list-style-type: none"> <li>1. Michaelis-Menten kinetics</li> <li>2. Enzyme regulation</li> <li>3. Enzyme nomenclature</li> </ol> </li> <li>4. Cofactors and cosubstrates, vitamins</li> <li>5. Metabolism: <ol style="list-style-type: none"> <li>1. Basic principles</li> <li>2. Photosynthesis</li> <li>3. Glycolysis</li> <li>4. Citric acid cycle</li> <li>5. Respiration</li> <li>6. Anaerobic respirations</li> <li>7. Fatty acid metabolism</li> <li>8. Amino acid metabolism</li> </ol> </li> </ol>
<b>Literature</b>	Biochemie, H. Robert Horton, Laurence A. Moran, K. Gray Scrimmeour, Marc D. Perry, J. David Rawn, Pearson Studium, München Prinzipien der Biochemie, A. L. Lehninger, de Gruyter Verlag Berlin

Course L0728: Biochemistry	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Dr. Paul Bubenheim
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. The molecular logic of Life</li> <li>2. Biomolecules: <ol style="list-style-type: none"> <li>1. Amino acids, peptides, proteins</li> <li>2. Carbohydrates</li> <li>3. Lipids</li> </ol> </li> <li>3. Protein functions, Enzymes: <ol style="list-style-type: none"> <li>1. Michaelis-Menten kinetics</li> <li>2. Enzyme regulation</li> <li>3. Enzyme nomenclature</li> </ol> </li> <li>4. Cofactors and cosubstrates, vitamins</li> <li>5. Metabolism: <ol style="list-style-type: none"> <li>1. Basic principles</li> <li>2. Photosynthesis</li> <li>3. Glycolysis</li> <li>4. Citric acid cycle</li> <li>5. Respiration</li> <li>6. Anaerobic respirations</li> <li>7. Fatty acid metabolism</li> <li>8. Amino acid metabolism</li> </ol> </li> </ol>
<b>Literature</b>	Biochemie, H. Robert Horton, Laurence A. Moran, K. Gray Scrimmeour, Marc D. Perry, J. David Rawn, Pearson Studium, München Prinzipien der Biochemie, A. L. Lehninger, de Gruyter Verlag Berlin

Course L0881: Microbiology	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Johannes Gescher
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>1. The procaryotic cell</p> <ul style="list-style-type: none"> <li>• evolution</li> <li>• taxonomy and specific properties of Archaea, Bacteria, and viruses</li> <li>• structure and properties of the cell</li> <li>• growth</li> </ul> <p>2. Metabolism</p> <ul style="list-style-type: none"> <li>• fermentation and anaerobic respiration</li> <li>• methanogenesis and the anaerobic food chain</li> <li>• degradation of polymers</li> <li>• chemolithotrophy</li> </ul> <p>3. Microorganisms in relation to the environment</p> <ul style="list-style-type: none"> <li>• chemotaxis and motility</li> <li>• Elemental cycle of carbon, nitrogen and sulfur</li> <li>• biofilms</li> <li>• symbiotic relationships</li> <li>• extremophiles</li> <li>• biotechnology</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• <b>Allgemeine Mikrobiologie</b>, 8. Aufl., 2007, Fuchs, G. (Hrsg.), Thieme Verlag (54,95 €)</li> <li>• <b>Mikrobiologie</b>, 13 Aufl., 2013, Madigan, M., Martinko, J. M., Stahl, D. A., Clark, D. P. (Hrsg.), ehemals „Brock“, Pearson Verlag (89,95 €)</li> <li>• Taschenlehrbuch Biologie <b>Mikrobiologie</b>, 2008, Munk, K. (Hrsg.), Thieme Verlag</li> <li>• <b>Grundlagen der Mikrobiologie</b>, 4. Aufl., 2010, Cypionka, H., Springer Verlag (29,95 €), <a href="http://www.grundlagen-der-mikrobiologie.icbm.de/">http://www.grundlagen-der-mikrobiologie.icbm.de/</a></li> </ul>

Course L0888: Microbiology	
<b>Typ</b>	Project-/problem-based Learning
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Johannes Gescher
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>1. The procaryotic cell</p> <ul style="list-style-type: none"> <li>• evolution</li> <li>• taxonomy and specific properties of Archaea, Bacteria, and viruses</li> <li>• structure and properties of the cell</li> <li>• growth</li> </ul> <p>2. Metabolism</p> <ul style="list-style-type: none"> <li>• fermentation and anaerobic respiration</li> <li>• methanogenesis and the anaerobic food chain</li> <li>• degradation of polymers</li> <li>• chemolithotrophy</li> </ul> <p>3. Microorganisms in relation to the environment</p> <ul style="list-style-type: none"> <li>• chemotaxis and motility</li> <li>• Elemental cycle of carbon, nitrogen and sulfur</li> <li>• biofilms</li> <li>• symbiotic relationships</li> <li>• extremophiles</li> <li>• biotechnology</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• <b>Allgemeine Mikrobiologie</b>, 8. Aufl., 2007, Fuchs, G. (Hrsg.), Thieme Verlag (54,95 €)</li> <li>• <b>Mikrobiologie</b>, 13 Aufl., 2013, Madigan, M., Martinko, J. M., Stahl, D. A., Clark, D. P. (Hrsg.), ehemals „Brock“, Pearson Verlag (89,95 €)</li> <li>• Taschenlehrbuch Biologie <b>Mikrobiologie</b>, 2008, Munk, K. (Hrsg.), Thieme Verlag</li> <li>• <b>Grundlagen der Mikrobiologie</b>, 4. Aufl., 2010, Cypionka, H., Springer Verlag (29,95 €), <a href="http://www.grundlagen-der-mikrobiologie.icbm.de/">http://www.grundlagen-der-mikrobiologie.icbm.de/</a></li> </ul>

Module M1277: MED I: Introduction to Anatomy				
Courses				
Title	Typ		Hrs/wk	CP
Introduction to Anatomy (L0384)	Lecture		2	3
<b>Module Responsible</b>	Prof. Udo Schumacher			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	None			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> The students can describe basal structures and functions of internal organs and the musculoskeletal system. The students can describe the basic macroscopy and microscopy of those systems.</p> <p><i>Skills</i> The students can recognize the relationship between given anatomical facts and the development of some common diseases; they can explain the relevance of structures and their functions in the context of widespread diseases.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> The students can participate in current discussions in biomedical research and medicine on a professional level.</p> <p><i>Autonomy</i> The students are able to access anatomical knowledge by themselves, can participate in conversations on the topic and acquire the relevant knowledge themselves.</p>			
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28			
<b>Credit points</b>	3			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 minutes			
<b>Assignment for the Following Curricula</b>	<p>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory</p> <p>Data Science: Specialisation Medicine: Compulsory</p> <p>Electrical Engineering: Specialisation Medical Technology: Elective Compulsory</p> <p>Engineering Science: Specialisation Biomedical Engineering: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory</p> <p>Mechanical Engineering: Specialisation Biomechanics: Compulsory</p> <p>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory</p> <p>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory</p> <p>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory</p> <p>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory</p> <p>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory</p>			

Course L0384: Introduction to Anatomy	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Tobias Lange
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p><b>General Anatomy</b></p> <p>1<sup>st</sup> week:        The Eucaryote Cell</p> <p>2<sup>nd</sup> week:        The Tissues</p> <p>3<sup>rd</sup> week:        Cell Cycle, Basics in Development</p> <p>4<sup>th</sup> week:        Musculoskeletal System</p> <p>5<sup>th</sup> week:        Cardiovascular System</p> <p>6<sup>th</sup> week:        Respiratory System</p> <p>7<sup>th</sup> week:        Genito-urinary System</p> <p>8<sup>th</sup> week:        Immune system</p> <p>9<sup>th</sup> week:        Digestive System I</p> <p>10<sup>th</sup> week:       Digestive System II</p> <p>11<sup>th</sup> week:       Endocrine System</p> <p>12<sup>th</sup> week:       Nervous System</p> <p>13<sup>th</sup> week:       Exam</p>
<b>Literature</b>	Adolf Faller/Michael Schünke, Der Körper des Menschen, 17. Auflage, Thieme Verlag Stuttgart, 2016

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
<b>Module Responsible</b>	Prof. Andreas Liese			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	none, module "organic chemistry", module "fundamentals for process engineering"			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	Students are able to 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.			
<i>Skills</i>	After successful completion of this module, students should be able to <ul style="list-style-type: none"> <li>describe different kinetic approaches for growth and substrate-uptake and to calculate the corresponding parameters</li> <li>predict qualitatively the influence of energy generation, regeneration of redox equivalents and growth inhibition on the fermentation process</li> <li>analyze bioprocesses on basis of stoichiometry and to set up / solve metabolic flux equations</li> <li>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</li> <li>propose solutions to complicated biotechnological problems and to deduce the corresponding models</li> <li>to explore new knowledge resources and to apply the newly gained contents</li> <li>identify scientific problems with concrete industrial use and to formulate solutions.</li> <li>to document and discuss their procedures as well as results in a scientific manner</li> </ul>			
<b>Personal Competence</b>				
<i>Social Competence</i>	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.			
<i>Autonomy</i>	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.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	5 %	Subject	theoretical and practical work
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 min			
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory 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 Endoprotheses: Elective Compulsory Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core Qualification: Compulsory			

Course L0841: Bioprocess Engineering - Fundamentals	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Andreas Liese
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction: state-of-the-art and development trends in the biotechnology, introduction to the lecture</li> <li>• Enzyme kinetics: Michaelis-Menten, different types of enzyme inhibition, linearization, conversion, yield, selectivity (Prof. Liese)</li> <li>• Stoichiometry: coefficient of respiration, electron balance, degree of reduction, coefficient of yield, theoretical oxygen demand (Prof. Liese)</li> <li>• Microbial growth kinetic: batch- and chemostat culture (Prof. Zeng)</li> <li>• Kinetic of substrate consumption and product formation (Prof. Zeng)</li> <li>• Rheology: non-newtonian fluids, viscosity, agitators, energy input (Prof. Liese)</li> <li>• Transport process in a bioreactor (Prof. Zeng)</li> <li>• Technology of sterilization (Prof. Zeng)</li> <li>• Fundamentals of bioprocess management: bioreactors and calculation of batch, fed-batch and continuous bioprocesses (Prof. Zeng/Prof. Liese)</li> <li>• Downstream technology in biotechnology: cell breakdown, centrifugation, filtration, aqueous two phase systems (Prof. Liese)</li> </ul>
<b>Literature</b>	<p>K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012</p> <p>H. Chmiel: Bioprozeßtechnik, Elsevier, 2006</p> <p>R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010</p> <p>H.W. Blanch, D. Clark: Biochemical Engineering, Taylor &amp; Francis, 1997</p> <p>P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013</p>

Course L0842: Bioprocess Engineering- Fundamentals	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 2, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Andreas Liese
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction (Prof. Liese, Prof. Zeng)</li> <li>2. Enzymatic kinetics (Prof. Liese)</li> <li>3. Stoichiometry I + II (Prof. Liese)</li> <li>4. Microbial Kinetics I+II (Prof. Zeng)</li> <li>5. Rheology (Prof. Liese)</li> <li>6. Mass transfer in bioprocess (Prof. Zeng)</li> <li>7. Continuous culture (Chemostat) (Prof. Zeng)</li> <li>8. Sterilisation (Prof. Zeng)</li> <li>9. Downstream processing (Prof. Liese)</li> <li>10. Repetition (Reserve) (Prof. Liese, Prof. Zeng)</li> </ol>
<b>Literature</b>	siehe Vorlesung

Course L0843: Bioprocess Engineering - Fundamental Practical Course	
<b>Typ</b>	Practical Course
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Andreas Liese, Prof. An-Ping Zeng
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>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.</p> <p>The students document their experiments and results in a protocol.</p>
<b>Literature</b>	Skript

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 Medicine: 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		

Course L0383: Introduction to Radiology and Radiation Therapy	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Ulrich Carl, Prof. Thomas Vestring
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	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
<b>Literature</b>	<ul style="list-style-type: none"> <li>• "Technik der medizinischen Radiologie" von T. + J. Laubenberg – 7. Auflage – Deutscher Ärzteverlag – erschienen 1999</li> <li>• "Klinische Strahlenbiologie" von Th. Herrmann, M. Baumann und W. Dörr – 4. Auflage - Verlag Urban &amp; Fischer – erschienen 02.03.2006 ISBN: 978-3-437-23960-1</li> <li>• "Strahlentherapie und Onkologie für MTA-R" von R. Sauer – 5. Auflage 2003 - Verlag Urban &amp; Schwarzenberg – erschienen 08.12.2009 ISBN: 978-3-437-47501-6</li> <li>• "Taschenatlas der Physiologie" von S. Silbernagel und A. Despopoulos- 8. Auflage – Georg Thieme Verlag - erschienen 19.09.2012 ISBN: 978-3-13-567708-8</li> <li>• "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</li> <li>• „Praxismanual Strahlentherapie“ von Stöver / Feyer – 1. Auflage - Springer-Verlag GmbH – erschienen 02.06.2000</li> </ul>

Module M0671: Technical Thermodynamics I			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
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
<b>Module Responsible</b>	Prof. Dr. Arne Speerforck		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Elementary knowledge in Mathematics and Mechanics		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	Students are familiar with the laws of Thermodynamics. They know the relation of the kinds of energy according to 1 <sup>st</sup> law of Thermodynamics and are aware about the limits of energy conversions according to 2 <sup>nd</sup> 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 energy. 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.		
<i>Skills</i>	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.		
<b>Personal Competence</b>			
<i>Social Competence</i>	The students are able to discuss in small groups and develop an approach.		
<i>Autonomy</i>	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90 min		
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Green Technologies: Energy, Water, Climate: 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Dr. Arne Speerforck
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction</li> <li>2. Fundamental terms</li> <li>3. Thermal Equilibrium and temperature <ol style="list-style-type: none"> <li>3.1 Thermal equation of state</li> </ol> </li> <li>4. First law <ol style="list-style-type: none"> <li>4.1 Heat and work</li> <li>4.2 First law for closed systems</li> <li>4.3 First law for open systems</li> <li>4.4 Examples</li> </ol> </li> <li>5. Equations of state and changes of state <ol style="list-style-type: none"> <li>5.1 Changes of state</li> <li>5.2 Cycle processes</li> </ol> </li> <li>6. Second law <ol style="list-style-type: none"> <li>6.1 Carnot process</li> <li>6.2 Entropy</li> <li>6.3 Examples</li> <li>6.4 Exergy</li> </ol> </li> <li>7. Thermodynamic properties of pure fluids <ol style="list-style-type: none"> <li>7.1 Fundamental equations of Thermodynamics</li> <li>7.2 Thermodynamic potentials</li> <li>7.3 Calorific state variables for arbitrary fluids</li> <li>7.4 state equations (van der Waals u.a.)</li> </ol> </li> </ol>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Schmitz, G.: Technische Thermodynamik, TuTech Verlag, Hamburg, 2009</li> <li>• Baehr, H.D.; Kabelac, S.: Thermodynamik, 15. Auflage, Springer Verlag, Berlin 2012</li> <li>• Potter, M.; Somerton, C.: Thermodynamics for Engineers, Mc GrawHill, 1993</li> </ul>

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

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

Module M0567: Theoretical Electrical Engineering I: Time-Independent Fields			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Theoretical Electrical Engineering I: Time-Independent Fields (L0180)	Lecture	3	5
Theoretical Electrical Engineering I: Time-Independent Fields (L0181)	Recitation Section (small)	2	1
<b>Module Responsible</b>	Prof. Christian Schuster		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Basic principles of electrical engineering and advanced mathematics		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	Students can explain the fundamental formulas, relations, and methods of the theory of time-independent electromagnetic fields. They can explicate the principal behavior of electrostatic, magnetostatic, and current density fields with regard to respective sources. They can describe the properties of complex electromagnetic fields by means of superposition of solutions for simple fields. The students are aware of applications for the theory of time-independent electromagnetic fields and are able to explicate these.		
<i>Skills</i>	Students can apply Maxwell's Equations in integral notation in order to solve highly symmetrical, time-independent, electromagnetic field problems. Furthermore, they are capable of applying a variety of methods that require solving Maxwell's Equations for more general problems. The students can assess the principal effects of given time-independent sources of fields and analyze these quantitatively. They can deduce meaningful quantities for the characterization of electrostatic, magnetostatic, and electrical flow fields (capacitances, inductances, resistances, etc.) from given fields and dimension them for practical applications.		
<b>Personal Competence</b>			
<i>Social Competence</i>	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively (e.g. during exercise sessions).		
<i>Autonomy</i>	Students are capable to gather necessary information from provided references and relate this information to the lecture. They are able to continually reflect their knowledge by means of activities that accompany the lecture, such as short oral quizzes during the lectures and exercises that are related to the exam. Based on respective feedback, students are expected to adjust their individual learning process. They are able to draw connections between their knowledge obtained in this lecture and the content of other lectures (e.g. Electrical Engineering I, Linear Algebra, and Analysis).		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90-150 minutes		
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory Electrical Engineering: Core Qualification: Compulsory Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory		

Course L0180: Theoretical Electrical Engineering I: Time-Independent Fields	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	5
<b>Workload in Hours</b>	Independent Study Time 108, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Christian Schuster
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- Maxwell's Equations in integral and differential notation</li> <li>- Boundary conditions</li> <li>- Laws of conservation for energy and charge</li> <li>- Classification of electromagnetic field properties</li> <li>- Integral characteristics of time-independent fields (R, L, C)</li> <li>- Generic approaches to solving Poisson's Equation</li> <li>- Electrostatic fields and specific methods of solving</li> <li>- Magnetostatic fields and specific methods of solving</li> <li>- Fields of electrical current density and specific methods of solving</li> <li>- Action of force within time-independent fields</li> <li>- Numerical methods for solving time-independent problems</li> </ul> <p>The practical application of numerical methods will be trained within specifically prepared lectures in an interactive manner using small MATLAB programs.</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- G. Lehner, "Elektromagnetische Feldtheorie: Für Ingenieure und Physiker", Springer (2010)</li> <li>- H. Henke, "Elektromagnetische Felder: Theorie und Anwendung", Springer (2011)</li> <li>- W. Nolting, "Grundkurs Theoretische Physik 3: Elektrodynamik", Springer (2011)</li> <li>- D. Griffiths, "Introduction to Electrodynamics", Pearson (2012)</li> <li>- J. Edminister, "Schaum's Outline of Electromagnetics", McGraw-Hill (2013)</li> <li>- Richard Feynman, "Feynman Lectures on Physics: Volume 2", Basic Books (2011)</li> </ul>

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

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
<b>Module Responsible</b>	Prof. Gerhard Bauch			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<p>Mathematics 1-3</p> <p>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.</p>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> The students are able to classify and describe signals and linear time-invariant (LTI) systems using methods of signal and system theory. They are able to apply the fundamental transformations of continuous-time and discrete-time signals and systems. They can describe and analyse deterministic signals and systems mathematically in both time and image domain. In particular, they understand the effects in time domain and image domain which are caused by the transition of a continuous-time signal to a discrete-time signal.</p> <p><i>Skills</i> The students are able to describe and analyse deterministic signals and linear time-invariant systems using methods of signal and system theory. They can analyse and design basic systems regarding important properties such as magnitude and phase response, stability, linearity etc.. They can assess the impact of LTI systems on the signal properties in time and frequency domain.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> The students can jointly solve specific problems.</p> <p><i>Autonomy</i> The students are able to acquire relevant information from appropriate literature sources. They can control their level of knowledge during the lecture period by solving tutorial problems, software tools, clicker system.</p>			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 min			
<b>Assignment for the Following Curricula</b>	<p>General Engineering Science (German program, 7 semester): Core Qualification: Compulsory</p> <p>Computer Science: Core Qualification: Compulsory</p> <p>Computer Science: Specialisation II. Mathematics and Engineering Science: Elective Compulsory</p> <p>Data Science: Core Qualification: Compulsory</p> <p>Electrical Engineering: Core Qualification: Compulsory</p> <p>Computational Science and Engineering: Core Qualification: Compulsory</p> <p>Mechanical Engineering: Specialisation Mechatronics: Elective Compulsory</p> <p>Mechatronics: Core Qualification: Compulsory</p> <p>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory</p>			

Course L0432: Signals and Systems	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Gerhard Bauch
<b>Language</b>	DE/EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction to signal and system theory</li> <li>• Signals <ul style="list-style-type: none"> <li>◦ Classification of signals <ul style="list-style-type: none"> <li>■ Continuous-time and discrete-time signals</li> <li>■ Analog and digital signals</li> <li>■ Deterministic and random signals</li> </ul> </li> <li>◦ Description of LTI systems by differential equations or difference equations, respectively</li> <li>◦ Basic properties of signals and operations on signals</li> <li>◦ Elementary signals</li> <li>◦ Distributions (Generalized Functions)</li> <li>◦ Power and energy of signals</li> <li>◦ Correlation functions of deterministic signals <ul style="list-style-type: none"> <li>■ Autocorrelation function</li> <li>■ Crosscorrelation function</li> <li>■ Orthogonal signals</li> <li>■ Applications of correlation</li> </ul> </li> </ul> </li> <li>• Linear time-invariant (LTI) systems <ul style="list-style-type: none"> <li>◦ Linearity</li> <li>◦ Time-invariance</li> </ul> </li> </ul>

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

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

Module 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
<b>Module Responsible</b>	Prof. Jürgen Grabe			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Modules : <ul style="list-style-type: none"> <li>• Mechanics I-II</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i> <i>Skills</i> <b>Personal Competence</b> <i>Social Competence</i> <i>Autonomy</i>	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. 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 able to prove the usability (settlements) for shallow foundations.			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	No	20 %	Attestation	
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	60 minutes			
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Jürgen Grabe
<b>Language</b>	DE
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Structure of the soil</li> <li>• Ground surveying</li> <li>• Composition and properties of the soil</li> <li>• Groundwater</li> <li>• One-dimensional compression</li> <li>• Spreading of stresses</li> <li>• Settlement calculation</li> <li>• Consolidation</li> <li>• Shear strength</li> <li>• Earth pressure</li> <li>• Slope failure</li> <li>• Ground failure</li> <li>• Suspension based earth trenches</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Vorlesungsumdruck, s. <a href="http://www.tu-harburg.de/gbt">www.tu-harburg.de/gbt</a></li> <li>• Grabe, J. (2004): Bodenmechanik und Grundbau</li> <li>• Gudehus, G. (1981): Bodenmechanik</li> <li>• Kolymbas, D. (1998): Geotechnik - Bodenmechanik und Grundbau</li> <li>• Grundbau-Taschenbuch, Teil 1, aktuelle Auflage</li> </ul>

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

Course L1493: Soil Mechanics	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Jürgen Grabe
<b>Language</b>	DE
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Thorsten Kern			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basics of mathematics, in particular complex numbers, integrals, differentials			
	Basics of electrical engineering and mechanical engineering			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> Students can to draw and explain the basic principles of electric and magnetic fields.</p> <p>They can describe the function of the standard types of electric machines and present the corresponding equations and characteristic curves. For typically used drives they can explain the major parameters of the energy efficiency of the whole system from the power grid to the driven engine.</p> <p><i>Skills</i> Students are able to calculate two-dimensional electric and magnetic fields in particular ferromagnetic circuits with air gap. For this they apply the usual methods of the design auf electric machines.</p> <p>They can calculate the operational performance of electric machines from their given characteristic data and selected quantities and characteristic curves. They apply the usual equivalent circuits and graphical methods.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> none</p> <p><i>Autonomy</i> Students are able independently to calculate electric and magnetic fields for applications. They are able to analyse independently the operational performance of electric machines from the characteristic data and they can calculate thereof selected quantities and characteristic curves.</p>			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Subject theoretical and practical work			
<b>Examination duration and scale</b>	Design of four machines and actuators, review of design files			
<b>Assignment for the Following Curricula</b>	<p>General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory</p> <p>Digital Mechanical Engineering: Core Qualification: Compulsory</p> <p>Electrical Engineering: Core Qualification: Elective Compulsory</p> <p>Energy and Environmental Engineering: Core Qualification: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering: Elective Compulsory</p> <p>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory</p> <p>Logistics and Mobility: Specialisation Engineering Science: Elective Compulsory</p> <p>Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory</p> <p>Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory</p> <p>Mechanical Engineering: Core Qualification: Elective Compulsory</p> <p>Mechatronics: Core Qualification: Compulsory</p> <p>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory</p> <p>Engineering and Management - Major in Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory</p> <p>Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory</p>			

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

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

Module M0696: Mechanics II: Mechanics of Materials				
Courses				
Title	Typ		Hrs/wk	CP
Mechanics II (L0493)	Lecture		2	2
Mechanics II (L0494)	Recitation Section (small)		2	2
Mechanics II (L1691)	Recitation Section (large)		2	2
<b>Module Responsible</b>	Prof. Christian Cyron			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Mechanics I			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> Having accomplished this module, the students know and understand the basic concepts of continuum mechanics and elastostatics, in particular stress, strain, constitutive laws, stretching, bending, torsion, failure analysis, energy methods and stability of structures.</p> <p><i>Skills</i> Having accomplished this module, the students are able to</p> <ul style="list-style-type: none"> <li>- apply the fundamental concepts of mathematical and mechanical modeling and analysis to problems of their choice</li> <li>- apply the basic methods of elastostatics to problems of engineering, in particular in the design of mechanical structures</li> <li>- to educate themselves about more advanced aspects of elastostatics</li> </ul>			
<b>Personal Competence</b>				
<i>Social Competence</i>				
<i>Autonomy</i>				
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 min			
<b>Assignment for the Following Curricula</b>	<p>General Engineering Science (German program, 7 semester): Core Qualification: Compulsory</p> <p>Civil- and Environmental Engineering: Core Qualification: Compulsory</p> <p>Bioprocess Engineering: Core Qualification: Compulsory</p> <p>Data Science: Specialisation Mechanics: Compulsory</p> <p>Digital Mechanical Engineering: Core Qualification: Compulsory</p> <p>Electrical Engineering: Core Qualification: Elective Compulsory</p> <p>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory</p> <p>Logistics and Mobility: Core Qualification: Compulsory</p> <p>Mechanical Engineering: Core Qualification: Compulsory</p> <p>Mechatronics: Core Qualification: Compulsory</p> <p>Orientation Studies: Core Qualification: Elective Compulsory</p> <p>Naval Architecture: Core Qualification: Compulsory</p> <p>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory</p> <p>Process Engineering: Core Qualification: Compulsory</p> <p>Engineering and Management - Major in Logistics and Mobility: Core Qualification: Compulsory</p>			

  

Course L0493: Mechanics II	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Christian Cyron
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>stresses and strains</p> <p>Hooke's law</p> <p>tension and compression</p> <p>torsion</p> <p>bending</p> <p>stability</p> <p>buckling</p> <p>energy methods</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Gross, D., Hauger, W., Schröder, J., Wall, W.A.: Technische Mechanik 1, Springer</li> <li>• Gross, D., Hauger, W., Schröder, J., Wall, W.A.: Technische Mechanik 2 Elastostatik, Springer</li> </ul>

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

Course L1691: Mechanics II	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Christian Cyron, Dr. Konrad Schneider
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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	<div><div>Knowledge</div><div>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.</div></div> <div><div>Skills</div><div>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.</div></div> <div><div>Personal Competence</div><div><div>Social Competence</div><div>The students are able to support each other to learn the very extensive specialist knowledge.</div><div>Autonomy</div><div>The students are able to make the timing and the operation steps to learn the specialist knowledge of a very extensive field.</div></div></div>			
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 Orientation Studies: Core Qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			

Course L0217: Building Physics	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Frank Schmidt-Döhl
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	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
<b>Literature</b>	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	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Frank Schmidt-Döhl
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

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

Course L0215: Principles of Building Materials	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Frank Schmidt-Döhl
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	Structure of building materials Effects of action Fundamentals of mechanical behaviour  Material testing  Principles of metals  Joining methods
<b>Literature</b>	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
<b>Module Responsible</b>	Dr. Dorothea Rechtenbach			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	none			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i>  <i>Skills</i>  <b>Personal Competence</b> <i>Social Competence</i>  <i>Autonomy</i>	<p>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.</p> <p>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.</p> <p>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.</p> <p>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.</p>			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 min			
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Civil- and Environmental Engineering: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			

Course L0460: Chemistry I+II	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 64, Study Time in Lecture 56
<b>Lecturer</b>	Dr. Christoph Wutz
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Chemistry I:</p> <ul style="list-style-type: none"> <li>- Structure of matter</li> <li>- Periodic table</li> <li>- Electronegativity</li> <li>- Chemical bonds</li> <li>- Solid compounds and solutions</li> <li>- Chemistry of water</li> <li>- Chemical reactions and equilibria</li> <li>- Acid-base reactions</li> <li>- Redox reactions</li> </ul> <p>Chemistry II:</p> <ul style="list-style-type: none"> <li>- Simple compounds of carbon, aliphatic hydrocarbons, aromatic hydrocarbons,</li> <li>- Alcohols, phenols, ether, aldehydes, ketones, carbonic acids, ester, amines, amino acids, fats, sugars</li> <li>- Reaction mechanisms, radical reactions, nucleophilic substitution, elimination reactions, addition reaction</li> <li>- Practical applications and examples</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- Blumenthal, Linke, Vieth: Chemie - Grundwissen für Ingenieure</li> <li>- Kickelbick: Chemie für Ingenieure (Pearson)</li> <li>- Mortimer: Chemie. Basiswissen der Chemie.</li> <li>- Brown, LeMay, Bursten: Chemie. Studieren kompakt.</li> <li>- Schmuck: Basisbuch Organische Chemie (Pearson)</li> </ul>

Course L0475: Chemistry I+II	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Dorothea Rechtenbach
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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	3
<b>Module Responsible</b>	Prof. Uwe Starossek			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Mechanics I, Mathematics I			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	After successfully completing this module, students can express the basic aspects of linear frame analysis of statically determinate systems.			
<i>Skills</i>	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.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students can <ul style="list-style-type: none"> <li>participate in subject-specific and interdisciplinary discussions,</li> <li>defend their own work results in front of others</li> <li>promote the scientific development of colleagues</li> <li>Furthermore, they can give and accept professional constructive criticism</li> </ul>			
<i>Autonomy</i>	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.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	No	10 %	Written elaboration	Hausübungen mit Testat, betreut durch Studentische Tutoren (Tutorium)
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 Minuten			
<b>Assignment for the Following Curricula</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Uwe Starossek
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Statically determinate structural systems</p> <ul style="list-style-type: none"> <li>basics: statically determinacy, equilibrium, method of sections</li> <li>forces: determination of support reactions and internal forces</li> <li>influence lines of forces</li> <li>displacements: calculation of discrete displacements and rotations, calculation of deflection curves</li> <li>principle of virtual displacements and virtual forces</li> <li>work-energy theorem</li> <li>differential equation of beam</li> </ul>
<b>Literature</b>	Krätzig, W.B., Harte, R., Meskouris, K., Wittek, U.: Tragwerke 1 - Theorie und Berechnungsmethoden statisch bestimmter Stabtragwerke. 4. Aufl., Springer, Berlin, 1999.

Course L0667: Structural Analysis I	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Uwe Starossek
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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	<div><div>Knowledge</div><div>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.</div></div> <div><div>Skills</div><div>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.</div></div> <div><div>Personal Competence</div><div><div>Social Competence</div><div>-</div><div>Autonomy</div><div>-</div></div></div>		
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	<div>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering: Compulsory</div> <div>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory</div> <div>General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory</div> <div>Data Science: Specialisation Materials Science: Compulsory</div> <div>Digital Mechanical Engineering: Core Qualification: Compulsory</div> <div>Energy and Environmental Engineering: Core Qualification: Compulsory</div> <div>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory</div> <div>Logistics and Mobility: Specialisation Engineering Science: Elective Compulsory</div> <div>Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory</div> <div>Mechanical Engineering: Core Qualification: Compulsory</div> <div>Mechatronics: Core Qualification: Compulsory</div> <div>Naval Architecture: Core Qualification: Compulsory</div> <div>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory</div> <div>Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory</div>		

Course L1085: Fundamentals of Materials Science I	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Jörg Weißmüller
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	
<b>Literature</b>	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)	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Bodo Fiedler, Prof. Gerold Schneider
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	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
<b>Literature</b>	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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Gregor Vonbun-Feldbauer, Prof. Stefan Müller
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Motivation: „Atoms in Mechanical Engineering?“</li> <li>• Basics: Force and Energy</li> <li>• The electromagnetic Interaction</li> <li>• „Detour“: Mathematics (complex e-funktion etc.)</li> <li>• The atom: Bohr's model of the atom</li> <li>• Chemical bounds</li> <li>• The multi part problem: Solutions and strategies</li> <li>• Descriptions of using statistical thermodynamics</li> <li>• Elastic theory of atoms</li> <li>• Consequences of atomar properties on makroskopic Properties: Discussion of examples (metals, semiconductors, hybrid systems)</li> </ul>
<b>Literature</b>	<p>Für den <b>Elektromagnetismus</b>:</p> <ul style="list-style-type: none"> <li>• Bergmann-Schäfer: „Lehrbuch der Experimentalphysik“, Band 2: „Elektromagnetismus“, de Gruyter</li> </ul> <p>Für die <b>Atomphysik</b>:</p> <ul style="list-style-type: none"> <li>• Haken, Wolf: „Atom- und Quantenphysik“, Springer</li> </ul> <p>Für die <b>Materialphysik und Elastizität</b>:</p> <ul style="list-style-type: none"> <li>• Hornbogen, Warlimont: „Metallkunde“, Springer</li> </ul>

Module M0808: Finite Elements Methods				
<b>Courses</b>				
<b>Title</b>	<b>Typ</b>		<b>Hrs/wk</b>	<b>CP</b>
Finite Element Methods (L0291)	Lecture		2	3
Finite Element Methods (L0804)	Recitation Section (large)		2	3
<b>Module Responsible</b>	Prof. Otto von Estorff			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> The students 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.</p> <p><i>Skills</i> 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.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students can work in small groups on specific problems to arrive at joint solutions.</p> <p><i>Autonomy</i> 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.</p>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	No	20 %	Midterm	
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 min			
<b>Assignment for the Following Curricula</b>	Civil Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory Aircraft Systems Engineering: Specialisation Air Transportation Systems: 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 Mechatronics: Core Qualification: Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Otto von Estorff
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- General overview on modern engineering</li> <li>- Displacement method</li> <li>- Hybrid formulation</li> <li>- Isoparametric elements</li> <li>- Numerical integration</li> <li>- Solving systems of equations (statics, dynamics)</li> <li>- Eigenvalue problems</li> <li>- Non-linear systems</li> <li>- Applications</li>   <li>- Programming of elements (Matlab, hands-on sessions)</li> <li>- Applications</li> </ul>
<b>Literature</b>	Bathe, K.-J. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin

Course L0804: Finite Element Methods	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Otto von Estorff
<b>Language</b>	EN
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. An-Ping Zeng			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Content of module "Biochemical Engineering I"			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	<p>After successful completion of this module, students should be able to</p> <ul style="list-style-type: none"> <li>describe and explain different kinetic approaches for growth and substrate-uptake</li> <li>identification of scientific problems with concrete industrial use (cultivation of microorganisms and mammalian cells)</li> <li>describe and explain important downstreaming steps for proteins and their application as well as basic immobilization methods</li> </ul>			
<i>Skills</i>	<p>After successful completion of this module, students should be able to</p> <ul style="list-style-type: none"> <li>to identify scientific questions or possible practical problems for concrete industrial applications (eg cultivation of microorganisms and animal cells ) and to formulate solutions ,</li> <li>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 microaerobically)</li> <li>to formulate questions for the analysis and optimization of real biotechnological production processes appropriate solutions ,</li> <li>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</li> <li>Establish material flow balance equations and solve them to determine the kinetic parameters of different approaches and to calculate immobilization and activity yields ,</li> <li>to select process control strategies (batch , fed-batch , continuity ) appropriately and to calculate basic types and evaluate them.</li> </ul>			
<b>Personal Competence</b>				
<i>Social Competence</i>	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.			
<i>Autonomy</i>	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.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 min			
<b>Assignment for the Following Curricula</b>	<p>General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory</p> <p>Bioprocess Engineering: Core Qualification: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory</p> <p>Green Technologies: Energy, Water, Climate: Specialisation Bioresource Technology: Elective Compulsory</p> <p>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory</p>			

Course L1107: Bioprocess Engineering - Advanced	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Prof. An-Ping Zeng
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction: state-of-the-art and development trends of microbial and biocatalytic bioprocesses, introduction to the lecture</li> <li>• Enzymatic process I: reactor types and criteria for industrial biotransformations (Prof. Liese)</li> <li>• Enzymatic process II (Prof. Liese)</li> <li>• Immobilization technologies: basic methods for isolated enzymes/ cells (Prof. Liese)</li> <li>• Anaerobic fermentation processes (Prof. Zeng)</li> <li>• Microaerobic bioprocesses: kinetics, energetics, optimal O<sub>2</sub>-supply and scale-up (Prof. Zeng)</li> <li>• Fedbatch process and cultivation with high cell density (Prof. Zeng)</li> <li>• Downstream processing of protein bioproduction: basics of chromatography, membrane filtration (Prof. Liese)</li> <li>• Cell culture technology and continuous culture: basics, kinetics, media, reactors (Prof. Zeng)</li> <li>• Problem-based learning with selected bioprocesses (Prof. Liese, Prof. Zeng)</li> </ul>
<b>Literature</b>	<p>K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012</p> <p>H. Chmiel: Bioprozeßtechnik, Elsevier, 2006</p> <p>R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010</p> <p>H.W. Blanch, D. Clark: Biochemical Engineering, Taylor &amp; Francis, 1997</p> <p>P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013</p> <p>Skripte für die Vorlesung</p>

Course L1108: Bioprocess Engineering - Advanced	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. An-Ping Zeng
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Introduction: state-of-the-art and development trends of microbial and biocatalytic bioprocesses, introduction to the lecture</li> <li>• Enzymatic process I: reactor types and criteria for industrial biotransformations (Prof. Liese)</li> <li>• Enzymatic process II (Prof. Liese)</li> <li>• Immobilization technologies: basic methods for isolated enzymes/ cells (Prof. Liese)</li> <li>• Anaerobic fermentation processes (Prof. Zeng)</li> <li>• Microaerobic bioprocesses: kinetics, energetics, optimal O<sub>2</sub>-supply and scale-up (Prof. Zeng)</li> <li>• Fedbatch process and cultivation with high cell density (Prof. Zeng)</li> <li>• Downstream processing of protein bioproduction: basics of chromatography, membrane filtration (Prof. Liese)</li> <li>• Cell culture technology and continuous culture: basics, kinetics, media, reactors (Prof. Zeng)</li> <li>• Problem-based learning with selected bioprocesses (Prof. Liese, Prof. Zeng)</li> </ul> <p>The students present exercises and discuss them with their fellow students and faculty staff. 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.</p>
<b>Literature</b>	<p>K. Buchholz, V. Kasche, U. Bornscheuer: Biocatalysts and Enzyme Technology, 2. Aufl. Wiley-VCH, 2012</p> <p>H. Chmiel: Bioprozeßtechnik, Elsevier, 2006</p> <p>R.H. Balz et al.: Manual of Industrial Microbiology and Biotechnology, 3. edition, ASM Press, 2010</p> <p>H.W. Blanch, D. Clark: Biochemical Engineering, Taylor &amp; Francis, 1997</p> <p>P. M. Doran: Bioprocess Engineering Principles, 2. edition, Academic Press, 2013</p> <p>Skripte für die Vorlesung</p>

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
<b>Module Responsible</b>	Prof. Hans-Jürgen Kreienkamp		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	None		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> The students can</p> <ul style="list-style-type: none"> <li>describe basic biomolecules;</li> <li>explain how genetic information is coded in the DNA;</li> <li>explain the connection between DNA and proteins;</li> </ul> <p><i>Skills</i> The students can</p> <ul style="list-style-type: none"> <li>recognize the importance of molecular parameters for the course of a disease;</li> <li>describe selected molecular-diagnostic procedures;</li> <li>explain the relevance of these procedures for some diseases</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> The students can participate in discussions in research and medicine on a technical level.</p> <p><i>Autonomy</i> The students can develop understanding of topics from the course, using technical literature, by themselves.</p>		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
<b>Credit points</b>	3		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	60 minutes		
<b>Assignment for the Following Curricula</b>	<p>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory</p> <p>Data Science: Specialisation Medicine: Compulsory</p> <p>Electrical Engineering: Specialisation Medical Technology: Elective Compulsory</p> <p>Engineering Science: Specialisation Biomedical Engineering: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory</p> <p>Mechanical Engineering: Specialisation Biomechanics: Compulsory</p> <p>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory</p> <p>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory</p> <p>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory</p> <p>Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory</p> <p>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory</p>		

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

Module M0783: Measurements: Methods and Data Processing				
<b>Courses</b>				
<b>Title</b>	<b>Typ</b>		<b>Hrs/wk</b>	<b>CP</b>
EE Experimental Lab (L0781)	Practical Course		2	2
Measurements: Methods and Data Processing (L0779)	Lecture		2	3
Measurements: Methods and Data Processing (L0780)	Recitation Section (small)		1	1
<b>Module Responsible</b>	Prof. Alexander Schlaefer			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	principles of mathematics principles of electrical engineering			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	The students are able to explain the purpose of metrology and the acquisition and processing of measurements. They can detail aspects of probability theory and errors, and explain the processing of stochastic signals. Students know methods to digitalize and describe measured signals.			
<i>Skills</i>	The students are able to evaluate problems of metrology and to apply methods for describing and processing of measurements.			
<b>Personal Competence</b>				
<i>Social Competence</i>	The students solve problems in small groups.			
<i>Autonomy</i>	The students can reflect their knowledge and discuss and evaluate their results.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	Yes	10 %	Exercises	
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 min			
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory Electrical Engineering: Core Qualification: Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			

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

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

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

Module 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. Dr. 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.				
Autonomy	Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice.				
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 Energy and Environmental 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 Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Process Engineering: Core Qualification: Compulsory				

Course L0449: Technical Thermodynamics II	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Dr. Arne Speerforck
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	8. Cycle processes 7. Gas - vapor - mixtures 10. Open systems with constant flow rates 11. Combustion processes 12. Special fields of Thermodynamics
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Schmitz, G.: Technische Thermodynamik, TuTech Verlag, Hamburg, 2009</li> <li>• Baehr, H.D.; Kabelac, S.: Thermodynamik, 15. Auflage, Springer Verlag, Berlin 2012</li> <li>• Potter, M.; Somerton, C.: Thermodynamics for Engineers, Mc GrawHill, 1993</li> </ul>

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

Course L0451: Technical Thermodynamics II	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Dr. Arne Speerforck
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0568: Theoretical Electrical Engineering II: Time-Dependent Fields			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Theoretical Electrical Engineering II: Time-Dependent Fields (L0182)	Lecture	3	5
Theoretical Electrical Engineering II: Time-Dependent Fields (L0183)	Recitation Section (small)	2	1
<b>Module Responsible</b>	Prof. Christian Schuster		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Electrical Engineering I, Electrical Engineering II, Theoretical Electrical Engineering I Mathematics I, Mathematics II, Mathematics III, Mathematics IV		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	Students are able to explain fundamental formulas, relations, and methods related to the theory of time-dependent electromagnetic fields. They can assess the principal behavior and characteristics of quasistationary and fully dynamic fields with regard to respective sources. They can describe the properties of complex electromagnetic fields by means of superposition of solutions for simple fields. The students are aware of applications for the theory of time-dependent electromagnetic fields and are able to explicate these.		
<i>Skills</i>	Students are able to apply a variety of procedures in order to solve the diffusion and the wave equation for general time-dependent field problems. They can assess the principal effects of given time-dependent sources of fields and analyze these quantitatively. They can deduce meaningful quantities for the characterization of fully dynamic fields (wave impedance, skin depth, Poynting-vector, radiation resistance, etc.) from given fields and interpret them with regard to practical applications.		
<b>Personal Competence</b>			
<i>Social Competence</i>	Students are able to work together on subject related tasks in small groups. They are able to present their results effectively (e.g. during exercise sessions).		
<i>Autonomy</i>	Students are capable to gather necessary information from provided references and relate this information to the lecture. They are able to continually reflect their knowledge by means of activities that accompany the lecture, such as short oral quizzes during the lectures and exercises that are related to the exam. Based on respective feedback, students are expected to adjust their individual learning process. They are able to draw connections between acquired knowledge and ongoing research at the Hamburg University of Technology (TUHH), e.g. in the area of high frequency engineering and optics.		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90-150 minutes		
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory Electrical Engineering: Core Qualification: Compulsory Technomathematics: Specialisation III, Engineering Science: Elective Compulsory		

Course L0182: Theoretical Electrical Engineering II: Time-Dependent Fields	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	5
<b>Workload in Hours</b>	Independent Study Time 108, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Christian Schuster
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- Theory and principal characteristics of quasistationary electromagnetic fields</li> <li>- Electromagnetic induction and law of induction</li> <li>- Skin effect and eddy currents</li> <li>- Shielding of time variable magnetic fields</li> <li>- Theory and principal characteristics of fully dynamic electromagnetic fields</li> <li>- Wave equations and properties of planar waves</li> <li>- Polarization and superposition of planar waves</li> <li>- Reflection and refraction of planar waves at boundary surfaces</li> <li>- Waveguide theory</li> <li>- Rectangular waveguide, planar optical waveguide</li> <li>- Electrical and magnetical dipol radiation</li> <li>- Simple arrays of antennas</li> </ul> <p>The practical application of numerical methods will be trained within specifically prepared lectures in an interactive manner using small MATLAB programs.</p>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- G. Lehner, "Elektromagnetische Feldtheorie: Für Ingenieure und Physiker", Springer (2010)</li> <li>- H. Henke, "Elektromagnetische Felder: Theorie und Anwendung", Springer (2011)</li> <li>- W. Nolting, "Grundkurs Theoretische Physik 3: Elektrodynamik", Springer (2011)</li> <li>- D. Griffiths, "Introduction to Electrodynamics", Pearson (2012)</li> <li>- J. Edminister, "Schaum's Outline of Electromagnetics", McGraw-Hill (2013)</li> <li>- Richard Feynman, "Feynman Lectures on Physics: Volume 2", Basic Books (2011)</li> </ul>

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

Module 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
<b>Module Responsible</b>	Prof. Irina Smirnova			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Basic knowledge: Technical Thermodynamics			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<ul style="list-style-type: none"> <li>The students are capable of explaining qualitative and determining quantitative heat transfer in procedural apparatus (e. g. heat exchanger, chemical reactors).</li> <li>They are capable of distinguish and characterize different kinds of heat transfer mechanisms namely heat conduction, heat transfer and thermal radiation.</li> <li>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.</li> <li>They are able to depict the analogy between heat- and mass transfer and to describe complex linked processes in detail.</li> </ul>			
<i>Knowledge</i>				
<i>Skills</i>				
<b>Personal Competence</b>				
<i>Social Competence</i>	<ul style="list-style-type: none"> <li>The students are able to work on subject-specific challenges in teams and to present the results orally in a reasonable manner to tutors and other students.</li> </ul>			
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>The students are able to find and evaluate necessary information from suitable sources</li> <li>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.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 minutes; theoretical questions and calculations			
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Process Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (German program, 7 semester): Specialisation Green Technologies: Compulsory General Engineering Science (German program, 7 semester): Specialisation Energy and Environmental Engineering: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Energy and Environmental Engineering: Core Qualification: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Energy and Environmental Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Process Engineering: 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Irina Smirnova
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ol style="list-style-type: none"> <li>Heat transfer <ul style="list-style-type: none"> <li>Introduction, one-dimensional heat conduction</li> <li>Convective heat transfer</li> <li>Multidimensional heat conduction</li> <li>Non-steady heat conduction</li> <li>Thermal radiation</li> </ul> </li> <li>Mass transfer <ul style="list-style-type: none"> <li>one-way diffusion, equimolar countercurrent diffusion</li> <li>boundary layer theory, non-steady mass transfer</li> <li>Heat and mass transfer single particle/ fixed bed</li> <li>Mass transfer and chemical reactions</li> </ul> </li> </ol>
<b>Literature</b>	<ol style="list-style-type: none"> <li>H.D. Baehr und K. Stephan: Wärme- und Stoffübertragung, Springer</li> <li>VDI-Wärmeatlas</li> </ol>

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

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

Module M0675: Introduction to Communications and Random Processes			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
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
<b>Module Responsible</b>	Prof. Gerhard Bauch		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Mathematics 1-3</li> <li>Signals and Systems</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	<p><i>Knowledge</i> The students know and understand the fundamental building blocks of a communications system. They can describe and analyse the individual building blocks using knowledge of signal and system theory as well as the theory of stochastic processes. They are aware of the essential resources and evaluation criteria of information transmission and are able to design and evaluate a basic communications system.</p> <p><i>Skills</i> The students are able to design and evaluate a basic communications system. In particular, they can estimate the required resources in terms of bandwidth and power. They are able to assess essential evaluation parameters of a basic communications system such as bandwidth efficiency or bit error rate and to decide for a suitable transmission method.</p> <p><i>Personal Competence</i></p> <p><i>Social Competence</i> The students can jointly solve specific problems.</p> <p><i>Autonomy</i> The students are able to acquire relevant information from appropriate literature sources. They can control their level of knowledge during the lecture period by solving tutorial problems, software tools, clicker system.</p>		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90 min		
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory Computer Science: Specialisation Computational Mathematics: Elective Compulsory Data Science: Core Qualification: Elective Compulsory Electrical Engineering: Core Qualification: Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory Computational Science and Engineering: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory		

Course L0442: Introduction to Communications and Random Processes	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Gerhard Bauch
<b>Language</b>	DE/EN
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>Fundamentals of random processes</li> <li>Introduction to communications engineering</li> <li>Quadrature amplitude modulation</li> <li>Description of radio frequency transmission in the equivalent complex baseband</li> <li>Transmission channels, channel models</li> <li>Analog digital conversion: Sampling, quantization, pulsecode modulation (PCM)</li> <li>Fundamentals of information theory, source coding, channel coding</li> <li>Digital baseband transmission: Pulse shaping, eye diagramm, 1. and 2. Nyquist condition, matched filter, detection, error probability</li> <li>Fundamentals of digital modulation</li> </ul>
<b>Literature</b>	<p>K. Kammeyer: Nachrichtenübertragung, Teubner</p> <p>P.A. Höher: Grundlagen der digitalen Informationsübertragung, Teubner.</p> <p>M. Bossert: Einführung in die Nachrichtentechnik, Oldenbourg.</p> <p>J.G. Proakis, M. Salehi: Grundlagen der Kommunikationstechnik. Pearson Studium.</p> <p>J.G. Proakis, M. Salehi: Digital Communications. McGraw-Hill.</p> <p>S. Haykin: Communication Systems. Wiley</p> <p>J.G. Proakis, M. Salehi: Communication Systems Engineering. Prentice-Hall.</p> <p>J.G. Proakis, M. Salehi, G. Bauch, Contemporary Communication Systems. Cengage Learning.</p>

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

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

Module M0959: Mechanics III (Dynamics)				
Courses				
Title		Typ	Hrs/wk	CP
Mechanics III (Dynamics) (L1134)		Lecture	3	3
Mechanics III (Dynamics) (L1135)		Recitation Section (small)	2	2
Mechanics III (Dynamics) (L1136)		Recitation Section (large)	1	1
Module Responsible	Prof. Robert Seifried			
Admission Requirements	None			
Recommended Previous Knowledge	Mathematics I, II, Mechanics I (Statics)			
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<div><div>Knowledge</div><div>The students can<ul style="list-style-type: none"><li>describe the axiomatic procedure used in mechanical contexts;</li><li>explain important steps in model design;</li><li>present technical knowledge in stereostatics.</li></ul></div><div><div>Skills</div><div>The students can<ul style="list-style-type: none"><li>explain the important elements of mathematical / mechanical analysis and model formation, and apply it to the context of their own problems;</li><li>apply basic hydrostatical, kinematic and kinetic methods to engineering problems;</li><li>estimate the reach and boundaries of statical methods and extend them to be applicable to wider problem sets.</li></ul></div><div><div>Personal Competence</div><div><div>Social Competence</div><div>The students can work in groups and support each other to overcome difficulties.</div><div><div>Autonomy</div><div>Students are capable of determining their own strengths and weaknesses and to organize their time and learning based on those.</div></div></div></div></div></div>			
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 Data Science: Core Qualification: Elective Compulsory Digital Mechanical Engineering: Core Qualification: Compulsory Energy and Environmental Engineering: Core Qualification: Elective Compulsory Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory Mechanical Engineering: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Naval Architecture: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			

Course L1134: Mechanics III (Dynamics)	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Robert Seifried
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	Kinematics <ul style="list-style-type: none"> <li>Kinematics of points and relative motion</li> <li>Planar and spatial motion of point systems and rigid bodies</li> </ul> Dynamics <ul style="list-style-type: none"> <li>Terms</li> <li>Fundamental equations</li> <li>Motion of the rigid body in 3D-space</li> <li>Dynamics of gyroscopes, rotors</li> <li>Relative kinetics</li> <li>Systems with non-constant mass</li> </ul> Vibrations <ul style="list-style-type: none"> <li></li> </ul>
<b>Literature</b>	K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009). D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 3 und 4. 11. Auflage, Springer (2011).

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

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

Module M0655: Computational Fluid Dynamics I			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Computational Fluid Dynamics I (L0235)	Lecture	2	3
Computational Fluid Dynamics I (L0419)	Recitation Section (large)	2	3
<b>Module Responsible</b>	Prof. Thomas Rung		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>Mathematical Methods for Engineers</li> <li>Fundamentals of Differential/integral calculus and series expansions</li> </ul>		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	The students are able to list the basic numerics of partial differential equations.		
<i>Skills</i>	The students are able develop appropriate numerical integration in space and time for the governing partial differential equations. They can code computational algorithms in a structured way.		
<b>Personal Competence</b>			
<i>Social Competence</i>	The students can arrive at work results in groups and document them.		
<i>Autonomy</i>	The students can independently analyse approaches to solving specific problems.		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	2h		
<b>Assignment for the Following Curricula</b>	<p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Naval Architecture: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Energy and Environmental Engineering: Compulsory</p> <p>Energy Systems: Technical Complementary Course Core Studies: Elective Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Energy and Environmental Engineering: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Elective Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Naval Architecture: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Elective Compulsory</p> <p>Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory</p> <p>Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory</p> <p>Naval Architecture: Core Qualification: Compulsory</p> <p>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory</p>		

Course L0235: Computational Fluid Dynamics I	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Thomas Rung
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Fundamentals of computational modelling of thermofluid dynamic problems. Development of numerical algorithms.</p> <ol style="list-style-type: none"> <li>1. Partial differential equations</li> <li>2. Foundations of finite numerical approximations</li> <li>3. Computation of potential flows</li> <li>4. Introduction of finite-differences</li> <li>5. Approximation of convective, diffusive and transient transport processes</li> <li>6. Formulation of boundary conditions and initial conditions</li> <li>7. Assembly and solution of algebraic equation systems</li> <li>8. Facets of weighted -residual approaches</li> <li>9. Finite volume methods</li> <li>10. Basics of grid generation</li> </ol>
<b>Literature</b>	Ferziger and Peric: <i>Computational Methods for Fluid Dynamics</i> , Springer

Course L0419: Computational Fluid Dynamics I	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Thomas Rung
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	See interlocking course
<b>Literature</b>	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
<b>Module Responsible</b>	Prof. Herbert Werner		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Representation of signals and systems in time and frequency domain, Laplace transform		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i> <ul style="list-style-type: none"> <li>Students can represent dynamic system behavior in time and frequency domain, and can in particular explain properties of first and second order systems</li> <li>They can explain the dynamics of simple control loops and interpret dynamic properties in terms of frequency response and root locus</li> <li>They can explain the Nyquist stability criterion and the stability margins derived from it.</li> <li>They can explain the role of the phase margin in analysis and synthesis of control loops</li> <li>They can explain the way a PID controller affects a control loop in terms of its frequency response</li> <li>They can explain issues arising when controllers designed in continuous time domain are implemented digitally</li> </ul> <i>Skills</i> <ul style="list-style-type: none"> <li>Students can transform models of linear dynamic systems from time to frequency domain and vice versa</li> <li>They can simulate and assess the behavior of systems and control loops</li> <li>They can design PID controllers with the help of heuristic (Ziegler-Nichols) tuning rules</li> <li>They can analyze and synthesize simple control loops with the help of root locus and frequency response techniques</li> <li>They can calculate discrete-time approximations of controllers designed in continuous-time and use it for digital implementation</li> <li>They can use standard software tools (Matlab Control Toolbox, Simulink) for carrying out these tasks</li> </ul> <b>Personal Competence</b> <i>Social Competence</i> Students can work in small groups to jointly solve technical problems, and experimentally validate their controller designs <i>Autonomy</i> 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.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	120 min		
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Core Qualification: Compulsory Bioprocess Engineering: Core Qualification: Compulsory Computer Science: Specialisation Computational Mathematics: Elective Compulsory Data Science: Core Qualification: Elective Compulsory Electrical Engineering: Core Qualification: Compulsory Energy and Environmental Engineering: Core Qualification: Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Civil Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Bioprocess Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Energy and Environmental Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Computer Science: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Energy Systems: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Aircraft Systems Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Naval Architecture: Compulsory General Engineering Science (English program, 7 semester): Specialisation Process Engineering: Compulsory		

	<p>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory</p> <p>Green Technologies: Energy, Water, Climate: Core Qualification: Compulsory</p> <p>Computational Science and Engineering: Core Qualification: Compulsory</p> <p>Logistics and Mobility: Specialisation Engineering Science: Elective Compulsory</p> <p>Logistics and Mobility: Specialisation Information Technology: Elective Compulsory</p> <p>Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory</p> <p>Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory</p> <p>Mechanical Engineering: Core Qualification: Compulsory</p> <p>Mechatronics: Core Qualification: Compulsory</p> <p>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory</p> <p>Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory</p> <p>Process Engineering: Core Qualification: Compulsory</p> <p>Engineering and Management - Major in Logistics and Mobility: Specialisation Information Technology: Elective Compulsory</p> <p>Engineering and Management - Major in Logistics and Mobility: Specialisation Traffic Planning and Systems: Elective Compulsory</p> <p>Engineering and Management - Major in Logistics and Mobility: Specialisation Production Management and Processes: Elective Compulsory</p>
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Course L0654: Introduction to Control Systems	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 92, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Herbert Werner
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Signals and systems</p> <ul style="list-style-type: none"> <li>Linear systems, differential equations and transfer functions</li> <li>First and second order systems, poles and zeros, impulse and step response</li> <li>Stability</li> </ul> <p>Feedback systems</p> <ul style="list-style-type: none"> <li>Principle of feedback, open-loop versus closed-loop control</li> <li>Reference tracking and disturbance rejection</li> <li>Types of feedback, PID control</li> <li>System type and steady-state error, error constants</li> <li>Internal model principle</li> </ul> <p>Root locus techniques</p> <ul style="list-style-type: none"> <li>Root locus plots</li> <li>Root locus design of PID controllers</li> </ul> <p>Frequency response techniques</p> <ul style="list-style-type: none"> <li>Bode diagram</li> <li>Minimum and non-minimum phase systems</li> <li>Nyquist plot, Nyquist stability criterion, phase and gain margin</li> <li>Loop shaping, lead lag compensation</li> <li>Frequency response interpretation of PID control</li> </ul> <p>Time delay systems</p> <ul style="list-style-type: none"> <li>Root locus and frequency response of time delay systems</li> <li>Smith predictor</li> </ul> <p>Digital control</p> <ul style="list-style-type: none"> <li>Sampled-data systems, difference equations</li> <li>Tustin approximation, digital implementation of PID controllers</li> </ul> <p>Software tools</p> <ul style="list-style-type: none"> <li>Introduction to Matlab, Simulink, Control toolbox</li> <li>Computer-based exercises throughout the course</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>Werner, H., Lecture Notes „Introduction to Control Systems“</li> <li>G.F. Franklin, J.D. Powell and A. Emami-Naeini "Feedback Control of Dynamic Systems", Addison Wesley, Reading, MA, 2009</li> <li>K. Ogata "Modern Control Engineering", Fourth Edition, Prentice Hall, Upper Saddle River, NJ, 2010</li> <li>R.C. Dorf and R.H. Bishop, "Modern Control Systems", Addison Wesley, Reading, MA 2010</li> </ul>

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

Module M1333: BIO I: Implants and Fracture Healing			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Implants and Fracture Healing (L0376)	Lecture	2	3
<b>Module Responsible</b>	Prof. Michael Morlock		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	It is recommended to participate in "Introduction into Anatomie" before attending "Implants and Fracture Healing".		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	The students can 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.		
<i>Skills</i>	The students can determine the forces acting within the human body under quasi-static situations under specific assumptions.		
<b>Personal Competence</b>			
<i>Social Competence</i>	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.		
<i>Autonomy</i>	The students can, in groups, solve basic numerical modeling tasks for the calculation of internal forces.		
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28		
<b>Credit points</b>	3		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	90 min		
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation 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 General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Biomedical Engineering: Specialisation Implants and Endoprotheses: 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	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Michael Morlock
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<p>Topics to be covered include:</p> <ol style="list-style-type: none"> <li>1. Introduction (history, definitions, background importance)</li> <li>2. Bone (anatomy, properties, biology, adaptations in femur, tibia, humerus, radius)</li> <li>3. Spine (anatomy, biomechanics, function, vertebral bodies, intervertebral disc, ligaments) <ol style="list-style-type: none"> <li>3.1 The spine in its entirety</li> <li>3.2 Cervical spine</li> <li>3.3 Thoracic spine</li> <li>3.4 Lumbar spine</li> <li>3.5 Injuries and diseases</li> </ol> </li> <li>4. Pelvis (anatomy, biomechanics, fracture treatment)</li> <li>5 Fracture Healing <ol style="list-style-type: none"> <li>5.1 Basics and biology of fracture repair</li> <li>5.2 Clinical principals and terminology of fracture treatment</li> <li>5.3 Biomechanics of fracture treatment <ol style="list-style-type: none"> <li>5.3.1 Screws</li> <li>5.3.2 Plates</li> <li>5.3.3 Nails</li> <li>5.3.4 External fixation devices</li> <li>5.3.5 Spine implants</li> </ol> </li> <li>6.0 New Implants</li> </ol> </li> </ol>
<b>Literature</b>	<p>Cochran V.B.: Orthopädische Biomechanik</p> <p>Mow V.C., Hayes W.C.: Basic Orthopaedic Biomechanics</p> <p>White A.A., Panjabi M.M.: Clinical biomechanics of the spine</p> <p>Nigg, B.: Biomechanics of the musculo-skeletal system</p> <p>Schiebler T.H., Schmidt W.: Anatomie</p> <p>Platzer: dtv-Atlas der Anatomie, Band 1 Bewegungsapparat</p>

Module M0708: Electrical Engineering III: Circuit Theory and Transients				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Circuit Theory (L0566)		Lecture	3	4
Circuit Theory (L0567)		Recitation Section (small)	2	2
<b>Module Responsible</b>	Prof. Alexander Kölpin			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Electrical Engineering I and II, Mathematics I and II			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	Students are able to explain the basic methods for calculating electrical circuits. They know the Fourier series analysis of linear networks driven by periodic signals. They know the methods for transient analysis of linear networks in time and in frequency domain, and they are able to explain the frequency behaviour and the synthesis of passive two-terminal-circuits.			
<i>Skills</i>	The students are able to calculate currents and voltages in linear networks by means of basic methods, also when driven by periodic signals. They are able to calculate transients in electrical circuits in time and frequency domain and are able to explain the respective transient behaviour. They are able to analyse and to synthesize the frequency behaviour of passive two-terminal-circuits.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students work on exercise tasks in small guided groups. They are encouraged to present and discuss their results within the group.			
<i>Autonomy</i>	The students are able to find out the required methods for solving the given practice problems. Possibilities are given to test their knowledge during the lectures continuously by means of short-time tests. This allows them to control independently their educational objectives. They can link their gained knowledge to other courses like Electrical Engineering I and Mathematics I.			
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	150 min			
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory Electrical Engineering: Core Qualification: Compulsory Engineering Science: Specialisation Electrical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Mechatronics: Compulsory Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Mechatronics: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			

Course L0566: Circuit Theory	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Alexander Kölpin, Dr. Fabian Lurz
<b>Language</b>	DE
<b>Cycle</b>	WiSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- Circuit theorems</li> <li>- N-port circuits</li> <li>- Periodic excitation of linear circuits</li> <li>- Transient analysis in time domain</li> <li>- Transient analysis in frequency domain; Laplace Transform</li> <li>- Frequency behaviour of passive one-ports</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>- M. Albach, "Grundlagen der Elektrotechnik 1", Pearson Studium (2011)</li> <li>- M. Albach, "Grundlagen der Elektrotechnik 2", Pearson Studium (2011)</li> <li>- L. P. Schmidt, G. Schaller, S. Martius, "Grundlagen der Elektrotechnik 3", Pearson Studium (2011)</li> <li>- T. Harriehausen, D. Schwarzenau, "Moeller Grundlagen der Elektrotechnik", Springer (2013)</li> <li>- A. Hambley, "Electrical Engineering: Principles and Applications", Pearson (2008)</li> <li>- R. C. Dorf, J. A. Svoboda, "Introduction to electrical circuits", Wiley (2006)</li> <li>- L. Moura, I. Darwazeh, "Introduction to Linear Circuit Analysis and Modeling", Amsterdam Newnes (2005)</li> </ul>

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

Module M0755: Geotechnics II				
Courses				
Title	Typ		Hrs/wk	CP
Foundation Engineering (L0552)	Lecture		2	2
Foundation Engineering (L0553)	Recitation Section (large)		2	2
Foundation Engineering (L1494)	Recitation Section (small)		2	2
<b>Module Responsible</b>	Prof. Jürgen Grabe			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Modules: <ul style="list-style-type: none"> <li>• Mechanics I-II</li> <li>• Geotechnics I</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i> <i>Skills</i>  <b>Personal Competence</b> <i>Social Competence</i> <i>Autonomy</i>	The students know the basic principles and methods which are required to verificate the stability of geotechnical structures. After successful completion of the module the students are able to: <ul style="list-style-type: none"> <li>• verificate the stability and usability of foundations,</li> <li>• know individual methods of ground improvement and apply them in their range of application,</li> <li>• design retaining walls.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	No	20 %	Attestation	
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	60 minutes			
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Civil Engineering: Elective Compulsory General Engineering Science (German program, 7 semester): Specialisation Civil Engineering: Elective Compulsory Civil- and Environmental Engineering: Core Qualification: Compulsory Civil- and Environmental Engineering: Specialisation Civil Engineering: Compulsory Civil- and Environmental Engineering: Specialisation Traffic and Mobility: Elective Compulsory Civil- and Environmental Engineering: Specialisation Water and Environment: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Civil Engineering: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			

Course L0552: Foundation Engineering	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Jürgen Grabe
<b>Language</b>	DE
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Shallow foundations</li> <li>• Pile foundations</li> <li>• Ground improvement</li> <li>• Retaining walls</li> <li>• Underpinning</li> <li>• Groundwater Conservation</li> <li>• Cut-off Walls</li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Vorlesung/Übung s. <a href="http://www.tu-harburg.de/gbt">www.tu-harburg.de/gbt</a></li> <li>• Grabe, J. (2004): Bodenmechanik und Grundbau</li> <li>• Kolymbas, D. (1998): Geotechnik - Bodenmechanik und Grundbau</li> <li>• Grundbau-Taschenbuch, neueste Auflage</li> </ul>

Course L0553: Foundation Engineering	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Jürgen Grabe
<b>Language</b>	DE
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L1494: Foundation Engineering	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Jürgen Grabe
<b>Language</b>	DE
<b>Cycle</b>	WiSe/SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0807: Boundary Element Methods				
<b>Courses</b>				
<b>Title</b>	<b>Typ</b>		<b>Hrs/wk</b>	<b>CP</b>
Boundary Element Methods (L0523)	Lecture		2	3
Boundary Element Methods (L0524)	Recitation Section (large)		2	3
<b>Module Responsible</b>	Prof. Otto von Estorff			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics) Mathematics I, II, III (in particular differential equations)			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> The students possess an in-depth knowledge regarding the derivation of the boundary element method and are able to give an overview of the theoretical and methodical basis of the method.</p> <p><i>Skills</i> The students are capable to handle engineering problems by formulating suitable boundary elements, assembling the corresponding system matrices, and solving the resulting system of equations.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students can work in small groups on specific problems to arrive at joint solutions.</p> <p><i>Autonomy</i> The students are able to independently solve challenging computational problems and develop own boundary element routines. Problems can be identified and the results are critically scrutinized.</p>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	<b>Compulsory</b>	<b>Bonus</b>	<b>Form</b>	<b>Description</b>
	No	20 %	Midterm	
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	90 min			
<b>Assignment for the Following Curricula</b>	Civil Engineering: Specialisation Structural Engineering: Elective Compulsory Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory Energy Systems: Core Qualification: Elective Compulsory Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory			

Course L0523: Boundary Element Methods	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Otto von Estorff
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>- Boundary value problems</li> <li>- Integral equations</li> <li>- Fundamental Solutions</li> <li>- Element formulations</li> <li>- Numerical integration</li> <li>- Solving systems of equations (statics, dynamics)</li> <li>- Special BEM formulations</li> <li>- Coupling of FEM and BEM</li> <li>- Hands-on Sessions (programming of BE routines)</li> <li>- Applications</li> </ul>
<b>Literature</b>	Gaul, L.; Fiedler, Ch. (1997): Methode der Randelemente in Statik und Dynamik. Vieweg, Braunschweig, Wiesbaden Bathe, K.-J. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin

Course L0524: Boundary Element Methods	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Otto von Estorff
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0734: Electrical Engineering Project Laboratory				
Courses				
Title	Typ		Hrs/wk	CP
Electrical Engineering Project Laboratory (L0640)	Project-/problem-based Learning		8	6
<b>Module Responsible</b>	Prof. Christian Becker			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Electrical Engineering I, Electrical Engineering II			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> Students are able to give a summary of the technical details of projects in the area of electrical engineering and illustrate respective relationships. They are capable of describing and communicating relevant problems and questions using appropriate technical language. They can explain the typical process of solving practical problems and present related results.</p> <p><i>Skills</i> The students can transfer their fundamental knowledge on electrical engineering to the process of solving practical problems. They identify and overcome typical problems during the realization of projects in the context of electrical engineering. Students are able to develop, compare, and choose conceptual solutions for non-standardized problems.</p> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> Students are able to cooperate in small, mixed-subject groups in order to independently derive solutions to given problems in the context of electrical engineering. They are able to effectively present and explain their results alone or in groups in front of a qualified audience. Students have the ability to develop alternative approaches to an electrical engineering problem independently or in groups and discuss advantages as well as drawbacks.</p> <p><i>Autonomy</i> Students are capable of independently solving electrical engineering problems using provided literature. They are able to fill gaps in as well as extend their knowledge using the literature and other sources provided by the supervisor. Furthermore, they can meaningfully extend given problems and pragmatically solve them by means of corresponding solutions and concepts.</p>			
<b>Workload in Hours</b>	Independent Study Time 68, Study Time in Lecture 112			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Subject theoretical and practical work			
<b>Examination duration and scale</b>	based on task + presentation			
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Electrical Engineering: Compulsory Electrical Engineering: Core Qualification: Compulsory Engineering Science: Specialisation Electrical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Electrical Engineering: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory			

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

Module M1280: MED II: Introduction to Physiology				
Courses				
Title	Typ		Hrs/wk	CP
Introduction to Physiology (L0385)	Lecture		2	3
<b>Module Responsible</b>	Dr. Roger Zimmermann			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	None			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> The students can</p> <ul style="list-style-type: none"> <li>describe the basics of the energy metabolism;</li> <li>describe physiological relations in selected fields of muscle, heart/circulation, neuro- and sensory physiology.</li> </ul> <p><i>Skills</i> 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.</p> <p><i>Personal Competence</i></p> <p><i>Social Competence</i> 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.</p> <p><i>Autonomy</i> The students can derive answers to questions arising in the course and other physiological areas, using technical literature, by themselves.</p>			
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28			
<b>Credit points</b>	3			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	60 minutes			
<b>Assignment for the Following Curricula</b>	<p>General Engineering Science (German program, 7 semester): Specialisation Biomedical Engineering: Compulsory</p> <p>General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory</p> <p>Data Science: Specialisation Medicine: Compulsory</p> <p>Electrical Engineering: Specialisation Medical Technology: Elective Compulsory</p> <p>Engineering Science: Specialisation Biomedical Engineering: Elective Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Biomechanics: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory</p> <p>General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Elective Compulsory</p> <p>Mechanical Engineering: Specialisation Biomechanics: Compulsory</p> <p>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory</p> <p>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory</p> <p>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory</p> <p>Biomedical Engineering: Specialisation Implants and Endoprotheses: Elective Compulsory</p> <p>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory</p>			

  

Course L0385: Introduction to Physiology	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Dr. Gerhard Engler
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	<p>Taschenatlas der Physiologie, Silbernagl Despopoulos, ISBN 978-3-135-67707-1, Thieme</p> <p>Repetitorium Physiologie, Speckmann, ISBN 978-3-437-42321-5, Elsevier</p>

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. Otto von Estorff			
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	Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: 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	Prof. Otto von Estorff
Language	EN
Cycle	SoSe
Content	- Introduction and Motivation - Acoustic quantities - Acoustic waves - Sound sources, sound radiation - Sound energy 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 )	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Otto von Estorff
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1005: Enhanced Fundamentals of Materials Science			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Enhanced Fundamentals: Ceramics and Polymers (L1233)	Lecture	2	2
Enhanced Fundamentals: Ceramics and Polymers (L1234)	Recitation Section (large)	1	1
Enhanced Fundamentals: Metals (L1086)	Lecture	2	3
<b>Module Responsible</b>	Prof. Gerold Schneider		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Module "Fundamentals of Materials Science" Module "Materials Science Laboratory" Module "Advanced Materials"		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>  <i>Skills</i>  <b>Personal Competence</b> <i>Social Competence</i> <i>Autonomy</i>	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.  The students are able to apply the appropriate physical and chemical methods for the above mentioned subjects.  The students are capable to understand independently the structure and properties of ceramics, metals and polymers. They should be able to critically evaluate the profoundness of their knowledge.		
<b>Workload in Hours</b>	Independent Study Time 110, Study Time in Lecture 70		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	180 min		
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory Data Science: Core Qualification: Elective Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Materials in Engineering Sciences: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Product Development and Production: Compulsory Mechanical Engineering: Specialisation Materials in Engineering Sciences: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory		

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

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

Course L1086: Enhanced Fundamentals: Metals	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Jörg Weißmüller
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p>Advanced understanding of metals:</p> <ul style="list-style-type: none"> <li>• Physical materials properties <ul style="list-style-type: none"> <li>◦ Materials behaviour - elastic, thermal, electrical</li> <li>◦ Superelasticity and shape memory effect</li> <li>◦ Fundamentals of electrical conductivity in metals and semiconductors</li> <li>◦ Superconductivity</li> </ul> </li> <li>• Chemical (or "dry") corrosion <ul style="list-style-type: none"> <li>◦ Driving forces and mechanisms</li> <li>◦ Passivation</li> <li>◦ Growth laws</li> </ul> </li> <li>• Introduction to electrochemistry <ul style="list-style-type: none"> <li>◦ Electrolytes</li> <li>◦ Ions</li> <li>◦ Solvation</li> <li>◦ Dissolution and deposition of metals</li> <li>◦ Galvanic cells and cell voltage</li> <li>◦ Galvanic series</li> <li>◦ Nernst equation</li> <li>◦ Polarizable electrodes</li> <li>◦ Electrochemical double layer</li> <li>◦ Capacitive and pseudocapacitive processes</li> <li>◦ Capacitive currents and Faraday currents</li> </ul> </li> <li>• Electrochemical (or "wet") corrosion and corrosion protection <ul style="list-style-type: none"> <li>◦ Basic observations</li> <li>◦ Galvanic corrosion</li> <li>◦ Protection against galvanic corrosion</li> <li>◦ Stainless steel</li> <li>◦ sacrificial anodes</li> <li>◦ Passivation and Pourbaix diagrams</li> <li>◦ Corrosion through gas reduction</li> <li>◦ Crevice corrosion</li> <li>◦ Stress corrosion cracking</li> <li>◦ Alloy corrosion and nanoporous metals</li> </ul> </li> <li>• Electrochemical energy storage <ul style="list-style-type: none"> <li>◦ How a battery works</li> <li>◦ Lead accumulators</li> <li>◦ Alkaline batteries</li> <li>◦ Nickel-metal hydride accumulators</li> <li>◦ Flux batteries</li> <li>◦ Lithium-ion accumulators</li> <li>◦ Electrolytic and super capacitors</li> <li>◦ Fuel cells</li> </ul> </li> <li>• Materials for hydrogen storage <ul style="list-style-type: none"> <li>◦ Storage strategies</li> <li>◦ Requirements for storage materials</li> <li>◦ State of the art</li> </ul> </li> <li>• Magnetism and magnetic materials <ul style="list-style-type: none"> <li>◦ Phenomenology: magnetic field and magnetization</li> <li>◦ Para-, ferro-, antiferromagnets; Curie transition</li> <li>◦ Magnetism at the atomic scale; exchange coupling</li> <li>◦ Magnetization isotherms, domains</li> <li>◦ Measurement methods</li> <li>◦ Magnetocrystalline anisotropy and domain walls</li> <li>◦ Hard magnetic materials and their applications</li> </ul> </li> </ul>

	<ul style="list-style-type: none"><li>o Soft magnetic materials and their applications</li></ul>
<b>Literature</b>	<ul style="list-style-type: none"><li>- Vorlesungsskript</li><li>- W.D. Callister, „Materialwissenschaften und Werkstofftechnik“, Wiley-VCH 2012</li><li>- Carl H. Hamann, Wolf Vielstich, "Elektrochemie", Wiley-VCH; 4. Auflage 2005</li><li>- Kurzweil, Dietlmeier, "Elektrochemische Speicher" Springer Vieweg (2015) (eBook: <a href="https://link.springer.com/book/10.1007/978-3-658-10900-4">https://link.springer.com/book/10.1007/978-3-658-10900-4</a> )</li><li>- B. D. Cullity, C.D. Graham, "Introduction to magnetic materials", John Wiley &amp; Sons, 2011</li><li>- D. Jiles, "Introduction to magnetism and magnetic materials", CRC press, 2015</li></ul>

Module M0606: Numerical Algorithms in Structural Mechanics				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Numerical Algorithms in Structural Mechanics (L0284)		Lecture	2	3
Numerical Algorithms in Structural Mechanics (L0285)		Recitation Section (small)	2	3
<b>Module Responsible</b>	Prof. Alexander Düster			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Knowledge of partial differential equations is recommended.			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>				
<i>Knowledge</i>	Students are able to + give an overview of 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.			
<i>Skills</i>	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 language (here C++). + critically judge and verify numerical algorithms.			
<b>Personal Competence</b>				
<i>Social Competence</i>	Students are able to + solve problems in heterogeneous groups and to document the corresponding results.			
<i>Autonomy</i>	Students are able to + acquire independently knowledge to solve complex problems.			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	2h			
<b>Assignment for the Following Curricula</b>	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: Technical Complementary Course: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory			

Course L0284: Numerical Algorithms in Structural Mechanics	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Alexander Düster
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	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
<b>Literature</b>	[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	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Alexander Düster
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0594: Fundamentals of Mechanical Engineering Design				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Fundamentals of Mechanical Engineering Design (L0258)		Lecture	2	3
Fundamentals of Mechanical Engineering Design (L0259)		Recitation Section (large)	2	3
<b>Module Responsible</b>	Prof. Dieter Krause			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	<ul style="list-style-type: none"> <li>• Basic knowledge about mechanics and production engineering</li> <li>• Internship (Stage I Practical)</li> </ul>			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b> <i>Knowledge</i>  <i>Skills</i>  <b>Personal Competence</b> <i>Social Competence</i>  <i>Autonomy</i>	<p>After passing the module, students are able to:</p> <ul style="list-style-type: none"> <li>• explain basic working principles and functions of machine elements,</li> <li>• explain requirements, selection criteria, application scenarios and practical examples of basic machine elements, indicate the background of dimensioning calculations.</li> </ul> <p>After passing the module, students are able to:</p> <ul style="list-style-type: none"> <li>• accomplish dimensioning calculations of covered machine elements,</li> <li>• transfer knowledge learned in the module to new requirements and tasks (problem solving skills),</li> <li>• recognize the content of technical drawings and schematic sketches,</li> <li>• technically evaluate basic designs.</li> </ul> <ul style="list-style-type: none"> <li>• Students are able to discuss technical information in the lecture supported by activating methods.</li> <li>• Students are able to independently deepen their acquired knowledge in exercises.</li> <li>• Students are able to acquire additional knowledge and to recapitulate poorly understood content e.g. by using the video recordings of the lectures.</li> </ul>			
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120			
<b>Assignment for the Following Curricula</b>	<p>General Engineering Science (German program, 7 semester): Core Qualification: Compulsory</p> <p>Digital Mechanical Engineering: Core Qualification: Compulsory</p> <p>Green Technologies: Energy, Water, Climate: Specialisation Energy Technology: Elective Compulsory</p> <p>Logistics and Mobility: Core Qualification: Compulsory</p> <p>Mechanical Engineering: Core Qualification: Compulsory</p> <p>Mechatronics: Core Qualification: Compulsory</p> <p>Orientation Studies: Core Qualification: Elective Compulsory</p> <p>Naval Architecture: Core Qualification: Compulsory</p> <p>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory</p>			

Course L0258: Fundamentals of Mechanical Engineering Design	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Dieter Krause, Prof. Josef Schlattmann, Prof. Otto von Estorff, Prof. Sören Ehlers
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<p><b>Lecture</b></p> <ul style="list-style-type: none"> <li>• Introduction to design</li> <li>• Introduction to the following machine elements <ul style="list-style-type: none"> <li>◦ Screws</li> <li>◦ Shaft-hub joints</li> <li>◦ Rolling contact bearings</li> <li>◦ Welding / adhesive / solder joints</li> <li>◦ Springs</li> <li>◦ Axes &amp; shafts</li> </ul> </li> <li>• Presentation of technical objects (technical drawing)</li> </ul> <p><b>Exercise</b></p> <ul style="list-style-type: none"> <li>• Calculation methods for dimensioning the following machine elements: <ul style="list-style-type: none"> <li>◦ Screws</li> <li>◦ Shaft-hub joints</li> <li>◦ Rolling contact bearings</li> <li>◦ Welding / adhesive / solder joints</li> <li>◦ Springs</li> <li>◦ Axis &amp; shafts</li> </ul> </li> </ul>
<b>Literature</b>	<ul style="list-style-type: none"> <li>• Dubbel, Taschenbuch für den Maschinenbau; Grote, K.-H., Feldhusen, J.(Hrsg.); Springer-Verlag, aktuelle Auflage.</li> <li>• Maschinenelemente, Band I-III; Niemann, G., Springer-Verlag, aktuelle Auflage.</li> <li>• Maschinen- und Konstruktionselemente; Steinhilper, W., Röper, R., Springer Verlag, aktuelle Auflage.</li> <li>• Einführung in die DIN-Normen; Klein, M., Teubner-Verlag.</li> <li>• Konstruktionslehre, Pahl, G.; Beitz, W., Springer-Verlag, aktuelle Auflage.</li> <li>• Maschinenelemente 1-2; Schlecht, B., Pearson Verlag, aktuelle Auflage.</li> <li>• Maschinenelemente - Gestaltung, Berechnung, Anwendung; Haberhauer, H., Bodenstein, F., Springer-Verlag, aktuelle Auflage.</li> <li>• Roloff/Matek Maschinenelemente; Wittel, H., Muhs, D., Jannasch, D., Voßiek, J., Springer Vieweg, aktuelle Auflage.</li> <li>• Sowie weitere Bücher zu speziellen Themen</li> </ul>

Course L0259: Fundamentals of Mechanical Engineering Design	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Dieter Krause, Prof. Josef Schlattmann, Prof. Otto von Estorff, Prof. Sören Ehlers
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0960: Mechanics IV (Oscillations, Analytical Mechanics, Multibody Systems, Numerical Mechanics)				
<b>Courses</b>				
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>	<b>CP</b>
Mechanics IV (Oscillations, Analytical Mechanics, Numerical Mechanics) (L1137)		Lecture	3	3
Mechanics IV (Oscillations, Analytical Mechanics, Numerical Mechanics) (L1138)		Recitation Section (small)	2	2
Mechanics IV (Oscillations, Analytical Mechanics, Numerical Mechanics) (L1139)		Recitation Section (large)	1	1
<b>Module Responsible</b>	Prof. Robert Seifried			
<b>Admission Requirements</b>	None			
<b>Recommended Previous Knowledge</b>	Mathematics I-III and Mechanics I-III			
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results			
<b>Professional Competence</b>	<p><i>Knowledge</i> The students can</p> <ul style="list-style-type: none"> <li>describe the axiomatic procedure used in mechanical contexts;</li> <li>explain important steps in model design;</li> <li>present technical knowledge.</li> </ul> <p><i>Skills</i> The students can</p> <ul style="list-style-type: none"> <li>explain the important elements of mathematical / mechanical analysis and model formation, and apply it to the context of their own problems;</li> <li>apply basic methods to engineering problems;</li> <li>estimate the reach and boundaries of the methods and extend them to be applicable to wider problem sets.</li> </ul> <p><b>Personal Competence</b></p> <p><i>Social Competence</i> The students can work in groups and support each other to overcome difficulties.</p> <p><i>Autonomy</i> Students are capable of determining their own strengths and weaknesses and to organize their time and learning based on those.</p>			
<b>Workload in Hours</b>	Independent Study Time 96, Study Time in Lecture 84			
<b>Credit points</b>	6			
<b>Course achievement</b>	None			
<b>Examination</b>	Written exam			
<b>Examination duration and scale</b>	120 min			
<b>Assignment for the Following Curricula</b>	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 Naval Architecture: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory Theoretical Mechanical Engineering: Technical Complementary Course Core Studies: Elective Compulsory			

Course L1137: Mechanics IV (Oscillations, Analytical Mechanics, Numerical Mechanics)	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 48, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Robert Seifried
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>Elements of vibration theory</li> <li>Vibration of Multi-degree of freedom systems</li> <li>Analytical Mechanics</li> <li>Multibody Systems</li> <li>Numerical methods for time integration</li> <li>Introduction to Matlab</li> </ul>
<b>Literature</b>	K. Magnus, H.H. Müller-Slany: Grundlagen der Technischen Mechanik. 7. Auflage, Teubner (2009). D. Gross, W. Hauger, J. Schröder, W. Wall: Technische Mechanik 1-4. 11. Auflage, Springer (2011). W. Schiehlen, P. Eberhard: Technische Dynamik, Springer (2012).

Course L1138: Mechanics IV (Oscillations, Analytical Mechanics, Numerical Mechanics)	
<b>Typ</b>	Recitation Section (small)
<b>Hrs/wk</b>	2
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 32, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Robert Seifried
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Course L1139: Mechanics IV (Oscillations, Analytical Mechanics, Numerical Mechanics)	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	1
<b>Workload in Hours</b>	Independent Study Time 16, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Robert Seifried
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M0777: Semiconductor Circuit Design			
<b>Courses</b>			
<b>Title</b>		<b>Typ</b>	<b>Hrs/wk</b>
Semiconductor Circuit Design (L0763)		Lecture	3
Semiconductor Circuit Design (L0864)		Recitation Section (small)	1
<b>Module Responsible</b>	Prof. Matthias Kuhl		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Fundamentals of electrical engineering Basics of physics, especially semiconductor physics		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>	<ul style="list-style-type: none"> <li>Students are able to explain the functionality of different MOS devices in electronic circuits.</li> <li>Students are able to explain how analog circuits functions and where they are applied.</li> <li>Students are able to explain the functionality of fundamental operational amplifiers and their specifications.</li> <li>Students know the fundamental digital logic circuits and can discuss their advantages and disadvantages.</li> <li>Students have knowledge about memory circuits and can explain their functionality and specifications.</li> <li>Students know the appropriate fields for the use of bipolar transistors.</li> </ul>		
<i>Skills</i>	<ul style="list-style-type: none"> <li>Students can calculate the specifications of different MOS devices and can define the parameters of electronic circuits.</li> <li>Students are able to develop different logic circuits and can design different types of logic circuits.</li> <li>Students can use MOS devices, operational amplifiers and bipolar transistors for specific applications.</li> </ul>		
<b>Personal Competence</b> <i>Social Competence</i>	<ul style="list-style-type: none"> <li>Students are able work efficiently in heterogeneous teams.</li> <li>Students working together in small groups can solve problems and answer professional questions.</li> </ul>		
<i>Autonomy</i>	<ul style="list-style-type: none"> <li>Students are able to assess their level of knowledge.</li> </ul>		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written exam		
<b>Examination duration and scale</b>	120 min		
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation 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 Mechanical Engineering, Focus Mechatronics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechatronics: Compulsory Computational Science and Engineering: Specialisation II. Mathematics & Engineering Science: Elective Compulsory Mechanical Engineering: Specialisation Mechatronics: Compulsory Mechatronics: Core Qualification: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory		

Course L0763: Semiconductor Circuit Design	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Matthias Kuhl
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Repetition Semiconductorphysics and Diodes</li> <li>• Functionality and characteristic curve of bipolar transistors</li> <li>• Basic circuits with bipolar transistors</li> <li>• Functionality and characteristic curve of MOS transistors</li> <li>• Basic circuits with MOS transistors for amplifiers</li> <li>• Operational amplifiers and their applications</li> <li>• Typical applications for analog and digital circuits</li> <li>• Realization of logical functions</li> <li>• Basic circuits with MOS transistors for combinational logic</li> <li>• Memory circuits</li> <li>• Basic circuits with MOS transistors for sequential logic</li> <li>• Basic concepts of analog-to-digital and digital-to-analog-converters</li> </ul>
<b>Literature</b>	<p>U. Tietze und Ch. Schenk, E. Gamm, Halbleiterschaltungstechnik, Springer Verlag, 14. Auflage, 2012, ISBN 3540428496</p> <p>R. J. Baker, CMOS - Circuit Design, Layout and Simulation, J. Wiley &amp; Sons Inc., 3. Auflage, 2011, ISBN: 0471700555</p> <p>H. Göbel, Einführung in die Halbleiter-Schaltungstechnik, Berlin, Heidelberg Springer-Verlag Berlin Heidelberg, 2011, ISBN: 9783642208874 ISBN: 9783642208867</p> <p>URL: <a href="http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10499499">http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10499499</a></p> <p>URL: <a href="http://dx.doi.org/10.1007/978-3-642-20887-4">http://dx.doi.org/10.1007/978-3-642-20887-4</a></p> <p>URL: <a href="http://ebooks.ciando.com/book/index.cfm/bok_id/319955">http://ebooks.ciando.com/book/index.cfm/bok_id/319955</a></p> <p>URL: <a href="http://www.ciando.com/img/bo">http://www.ciando.com/img/bo</a></p>

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

Module 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	<div><div>Knowledge</div><div>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.</div><div>Skills</div><div>The students can describe the basic handling of several experimental techniques used in biomechanics.</div><div>Personal Competence</div><div><div>Social Competence</div><div>The students can, in groups, solve basic experimental tasks.</div><div>Autonomy</div><div>The students can, in groups, solve basic experimental tasks.</div></div></div>					
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 Mechanical Engineering, Focus Biomechanics: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Compulsory General Engineering Science (English program, 7 semester): Specialisation Biomedical Engineering: Elective Compulsory Mechanical Engineering: Specialisation Biomechanics: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory					

Course L0377: Experimental Methods in Biomechanics	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	2
<b>CP</b>	3
<b>Workload in Hours</b>	Independent Study Time 62, Study Time in Lecture 28
<b>Lecturer</b>	Prof. Michael Morlock
<b>Language</b>	DE
<b>Cycle</b>	SoSe
<b>Content</b>	
<b>Literature</b>	Wird in der Veranstaltung bekannt gegeben

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

Course L0280: High-Order FEM	
<b>Typ</b>	Lecture
<b>Hrs/wk</b>	3
<b>CP</b>	4
<b>Workload in Hours</b>	Independent Study Time 78, Study Time in Lecture 42
<b>Lecturer</b>	Prof. Alexander Düster
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ol style="list-style-type: none"> <li>1. Introduction</li> <li>2. Motivation</li> <li>3. Hierarchic shape functions</li> <li>4. Mapping functions</li> <li>5. Computation of element matrices, assembly, constraint enforcement and solution</li> <li>6. Convergence characteristics</li> <li>7. Mechanical models and finite elements for thin-walled structures</li> <li>8. Computation of thin-walled structures</li> <li>9. Error estimation and hp-adaptivity</li> <li>10. High-order fictitious domain methods</li> </ol>
<b>Literature</b>	<p>[1] Alexander Düster, High-Order FEM, Lecture Notes, Technische Universität Hamburg-Harburg, 164 pages, 2014</p> <p>[2] Barna Szabo, Ivo Babuska, Introduction to Finite Element Analysis – Formulation, Verification and Validation, John Wiley &amp; Sons, 2011</p>

Course L0281: High-Order FEM	
<b>Typ</b>	Recitation Section (large)
<b>Hrs/wk</b>	1
<b>CP</b>	2
<b>Workload in Hours</b>	Independent Study Time 46, Study Time in Lecture 14
<b>Lecturer</b>	Prof. Alexander Düster
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	See interlocking course
<b>Literature</b>	See interlocking course

Module M1573: Modeling, Simulation and Optimization (EN)			
<b>Courses</b>			
<b>Title</b>	<b>Typ</b>		<b>Hrs/wk</b>
Modeling, Simulation and Optimization (L2446)	Integrated Lecture		4
<b>Module Responsible</b>	Prof. Benedikt Kriegesmann		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Sound knowledge of engineering mathematics, engineering mechanics and fluid mechanics		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>			
<i>Knowledge</i>	Students will have an overview of various technical problems and the differential equations, which describe them. Students will have an overview of different solution approaches and for which kind of problems they can be used for.		
<i>Skills</i>	Students are able to solve different technical problems with the introduced discretization methods.		
<b>Personal Competence</b>			
<i>Social Competence</i>	The students are able to discuss problems and jointly develop solution strategies.		
<i>Autonomy</i>	The students are able to develop solution strategies for complex problems self-consistent and critically analyse results.		
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Oral exam		
<b>Examination duration and scale</b>	30 min		
<b>Assignment for the Following Curricula</b>	General Engineering Science (German program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Compulsory Engineering Science: Core Qualification: Compulsory General Engineering Science (English program, 7 semester): Core Qualification: Compulsory General Engineering Science (English program, 7 semester): Specialisation Mechanical Engineering, Focus Theoretical Mechanical Engineering: Elective Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Elective Compulsory Mechanical Engineering: Specialisation Theoretical Mechanical Engineering: Compulsory Technomathematics: Specialisation III. Engineering Science: Elective Compulsory		

Course L2446: Modeling, Simulation and Optimization	
<b>Typ</b>	Integrated Lecture
<b>Hrs/wk</b>	4
<b>CP</b>	6
<b>Workload in Hours</b>	Independent Study Time 124, Study Time in Lecture 56
<b>Lecturer</b>	Prof. Benedikt Kriegesmann, Prof. Thomas Rung, Prof. Alexander Düster, Prof. Robert Seifried
<b>Language</b>	EN
<b>Cycle</b>	SoSe
<b>Content</b>	<ul style="list-style-type: none"> <li>• Partial Differential Equations in technical problems</li> <li>• Overview of modelling approaches</li> <li>• Finite Approximation Methods - Finite Differences / Elements / Volumes</li> <li>• Introduction to the Discrete Element Method</li> <li>• Numerical methods for time dependent problems</li> <li>• Gradient-based optimization</li> </ul>
<b>Literature</b>	Michael Schäfer, Computational Engineering - Introduction to Numerical Methods, Springer.

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**Specialization IV. Subject Specific Focus**


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

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

Module M1353: Mathematical Project Laboratory			
Courses			
Title	Typ	Hrs/wk	CP
<b>Module Responsible</b>	Dozenten der Mathematik		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	Analysis for Technomathematicians, Higher Analysis, Linear Algebra for Technomathematicians, Numerical Mathematics, Mathematical Stochastics, Mechanics für Technomathematicians, Elektrical Engineering for Technomathematicians, Procedural Programming, Objectoriented Programming, Algorithms and Data Structures		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b> <i>Knowledge</i>  <i>Skills</i>  <b>Personal Competence</b> <i>Social Competence</i>  <i>Autonomy</i>	<p>Students are able to evaluate in which cases the use of technomathematical knowledge can help to solve practical problems. For relevant questions, they have the necessary background and appropriate technical language at their disposal. They know the typical process of solving practical problems and are able to present related results.</p> <p>The students can transfer their fundamental knowledge concerning mathematics, engineering and computer science to the process of solving practical problems. They are able to build mathematical models for relevant, non-standard problems, they can develop and implement algorithmic strategies, and are able to document and present their results.</p> <p>Students are able to cooperate with partners from outside mathematics (e.g. in industry) to develop models and solutions for practical problems. They can present and explain these in front of a qualified audience. Students have the ability to develop alternative approaches and can discuss their advantages as well as their drawbacks.</p> <p>Students are capable of independently identifying practical problems that are suitable for the use of technomathematical methods and results. They can work their way into such problems, and are able to develop solutions under the guidance of their supervisor. They are able to fill in gaps as well as to extend their knowledge using provided sources. Furthermore, they can meaningfully extend given problems and solve them by means of concepts and approaches that they have to develop independently.</p>		
<b>Workload in Hours</b>	Independent Study Time 180, Study Time in Lecture 0		
<b>Credit points</b>	6		
<b>Course achievement</b>	None		
<b>Examination</b>	Written elaboration		
<b>Examination duration and scale</b>	Report, approx. 15 pages		
<b>Assignment for the Following Curricula</b>	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
<b>Module Responsible</b>	Prof. Anusch Taraz		
<b>Admission Requirements</b>	None		
<b>Recommended Previous Knowledge</b>	see selected module according to FSPO		
<b>Educational Objectives</b>	After taking part successfully, students have reached the following learning results		
<b>Professional Competence</b>	see selected module according to FSPO		
<i>Knowledge</i>			
<i>Skills</i>			
<b>Personal Competence</b>			
<i>Social Competence</i>			
<i>Autonomy</i>	see selected module according to FSPO		
<b>Workload in Hours</b>	Depends on choice of courses		
<b>Credit points</b>	6		
<b>Assignment for the Following Curricula</b>	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	<ul style="list-style-type: none"><li>According to General Regulations §21 (1):</li></ul> <p>At least 126 ECTS credit points have to be achieved in study programme. The examinations board decides on exceptions.</p>			
Recommended Previous Knowledge				
Educational Objectives	After taking part successfully, students have reached the following learning results			
Professional Competence	<ul style="list-style-type: none"><li>The students can select, outline and, if need be, critically discuss the most important scientific fundamentals of their course of study (facts, theories, and methods).</li><li>On the basis of their fundamental knowledge of their subject the students are capable in relation to a specific issue of opening up and establishing links with extended specialized expertise.</li><li>The students are able to outline the state of research on a selected issue in their subject area.</li></ul> <ul style="list-style-type: none"><li>The students can make targeted use of the basic knowledge of their subject that they have acquired in their studies to solve subject-related problems.</li><li>With the aid of the methods they have learnt during their studies the students can analyze problems, make decisions on technical issues, and develop solutions.</li><li>The students can take up a critical position on the findings of their own research work from a specialized perspective.</li></ul> <ul style="list-style-type: none"><li>Both in writing and orally the students can outline a scientific issue for an expert audience accurately, understandably and in a structured way.</li><li>The students can deal with issues in an expert discussion and answer them in a manner that is appropriate to the addressees. In doing so they can uphold their own assessments and viewpoints convincingly.</li></ul> <ul style="list-style-type: none"><li>The students are capable of structuring an extensive work process in terms of time and of dealing with an issue within a specified time frame.</li><li>The students are able to identify, open up, and connect knowledge and material necessary for working on a scientific problem.</li><li>The students can apply the essential techniques of scientific work to research of their own.</li></ul>			
Knowledge				
Skills				
Personal Competence				
Social Competence				
Autonomy				
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 Computer Science: Thesis: Compulsory Data Science: Thesis: Compulsory Digital Mechanical Engineering: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy and Environmental 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 Computational Science and Engineering: Thesis: Compulsory Logistics and Mobility: Thesis: Compulsory Mechanical Engineering: Thesis: Compulsory Mechatronics: Thesis: Compulsory Naval Architecture: Thesis: Compulsory Technomathematics: Thesis: Compulsory Teilstudiengang Lehramt Elektrotechnik-Informationstechnik: Thesis: Compulsory Teilstudiengang Lehramt Metalltechnik: Thesis: Compulsory Process Engineering: Thesis: Compulsory Engineering and Management - Major in Logistics and Mobility: Thesis: Compulsory			