TUHH
Hamburg
University of
Technology

Module Manual

Master of Science (M.Sc.)

Mechanical Engineering and Management

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Program description

Content

Nowadays engineers work not only as designers or as problem solvers in technical issues, but also fill management positions and have to make strategic and operative decisions. In addition to profound and specialized knowledge in diverse engineering fields, engineers also need a basic understanding in economics and business studies. Graduates, who already bring along both, specialized knowledge in engineering as well as a basic understanding of economic sciences, have excellent prospects in the labor market.

The international master study course “Mechanical Engineering and Management“ gives students with a bachelor´s degree in mechanical engineering or similar the opportunity to build up an individual profile within two specializations.

In the first specialization students gain basic knowledge in management, business administration, accounting as well as in specialized management topics, such as corporate management, human resources or logistics.

For the second specialization students can choose between three main topics: Materials, Mechatronics, or Product Development and Production. Because of the material behavior and its great impact on product design and manufacturing, the Materials specialization represents a bridge between natural science and engineering science. The Mechatronics specialization represents an interdisciplinary field between mechanics, electronics and computer science. The last specialization, Product Development and Production, includes the computation as well as the manufacturing of products. Therefore not only the structure of the master study course is interdisciplinary, but also its specializations.

Career prospects

The international master study course "Mechanical Engineering and Management" prepares graduates for a wide range of job profiles in international operating companies and in service providers, such as consulting. They are able to work as a facilitator between technical and business sectors and to take leading positions as technical and executive managers with budget and personnel responsibilities. The program is designed to be diverse and allows graduates to work in a variety of different industrial sectors (especially in mechanical engineering) and with different products and services. Graduates may decide for direct entry into companies or to take up academic careers, e.g. Ph.D. studies, in universities or other research institutions.

Learning target

Graduates of the program are able to transfer the individually acquired specialized knowledge to new unknown topics, to grasp, to analyze and to scientifically solve complex problems of their discipline. They can find missing information and plan as well as execute theoretical studies.

They are able to work independently in fields of mechanical engineering and management as well as in their interface. They can use their interdisciplinary understanding to evaluate and to critically question results and findings in management and mechanical engineering. Based upon these they can also make decisions and draw further conclusions. They are able to act methodically, to organize smaller projects, to select scientific methods and to advance these further, if necessary. They´re also qualified to work on challenging projects by considering and verifying existing information in two of these specializations:

- Management
- Materials
- Mechatronics
- Product Development and Production

In the following the learning target is divided in knowledge, skills, social skills and independence.

Knowledge

- Graduates have gained specialized interdisciplinary knowledge with broad theoretical and methodical foundations. This includes especially the compulsory courses in the first semester, in which they learn about Robotics, Computer Aided Design and Computation and Multiphase Materials.
- They have a fundamental understanding of business administration as well as special knowledge about diverse topics, such as marketing, intercultural communication or project management. They can describe different methods and current research in these fields.
- They are able to explain principles, methods and applications in detail of two engineering specializations. The engineering specializations are Materials, Mechatronics and Product Development and Production.
- They have gained basic knowledge in non-technical topics. Non-native German speaking graduates also learned the fundamentals of German language.
- They know the state of the art in their chosen specializations and can give an overview of applications in industry and research.

Skills

For all specializations

- Graduates are able to use their interdisciplinary understanding to solve complex problems through integrative linking. They can identify implications between economy and technology, mediate between these sectors and perform operative and strategic tasks.
- They are able to transfer their theoretical knowledge into practice, analyse management problems in complex corporate situations as well as to choose between advanced methods and procedures of material sience, mechatronics or computation and production and to use them for complex problems.
- They can estimate and evaluate future technologies, materials, methods and scientific findings and are able to research independently (qualified for Ph.D. studies).

Management specialization

- Graduates of the Management specialization are able to evaluate necessary business and financial key figures and to make decisions based on these.
- They are able to use diverse methods and techniques of management and business administration successfully for different tasks.

Materials specialization

- Graduates of the Materials can identify new application fields of materials and make choices between different materials in consideration of functions, cost and quality.
- They can calculate several material parameters and make constructive decisions upon these calculations.

Mechatronics specialization

- Graduates of the Mechatronics specialization can solve mechatronic tasks as well as design tasks systematically and methodically.

- They are able to use their knowledge about current methods, automation and simulation to analyze systems, evaluate the findings and to choose between different strategies to solve the task.

Product Development and Production specialization

- Graduates of the Product Development and Production specialization can choose between diverse manufacturing and production processes in consideration of geometry, failure control and cost.
- They are able to design, calculate and simulate according to the current state of the art.

Social Skills

- Graduates are able describe techniques, methods and findings of their work verbally and in written form in English.
- They can communicate with experts of their chosen disciplines and in their interdisciplinary interface as well as with lay persons about advanced contents and issues in English. They can also react appropriately to questions and comments.
- They are able to work in team. For this they can define, distribute and integrate subtasks and arrange team meetings. They can interact socially and are capable of taking leading positions.

Autonomy

- Graduates are capable of finding necessary information, extending their knowledge in technical, economic and social topics and putting these into context with their knowledge.
- They can systematically reflect the non-technical consequences of their work and can put their actions into socio-economic context.
- They can estimate their own strengths and weaknesses as well as possible consequences of their actions. They can compensate deficits and extend their knowledge independently as far as necessary.
- They can work self-organized and self-motivated in different research fields and find, analyze and define concrete problems within (lifelong learning).

Program structure

The course is designed modular and is based on the university-wide standardized course structure with uniform module sizes (multiples of six credit points (CP)). The course combines the engineering and management disciplines and allows the deepening in two of four specializations. The students can broadly personalize their studies due to high number and variety of elective courses.

In the common core skills, students take the following modules:

- Computer Aided Design and Computation (6 CP)
- Fibre-polymer-composites (6 CP)
- Robotics (6 CP)
- Management and complementary technical elective courses or an internship can be choosen (12 CP)
- Complementary courses business and management (catalog) (6 CP)
- Complementary nontechnical elective courses (catalog) (6 CP), of that 4 CP are intended for German classes

Students specialize by selecting two of the following areas, each covering 18 credit points. Students have to choose the Management specialization. Solely students of the Northern Institute of Technology have to choose two engineering specializations:

- Management (18 CP)
- Materials (18 CP)
- Mechatronics (18 CP)
- Product Development and Production (18 CP)

Within each area of specialization students can choose within a catalogue of modules (each 6 CP).

Students write also a master thesis and one additional scientific project work.

- Research Project (12 CP)
- Master thesis (30 CP)

Core Qualification

The core qualification provides the basic fundamentals for the four spcializations and also includes a catalogue of nontechnical elective complementary courses. For all three engineering specializations (Materials, Mechatronics, Product Development and Production) a compulsory module ist included. As preparation for the Management spezialization students choose three lecuters from the Business and Management catalogue and can also choose up to two more management related modules. Alternatively technical complementary courses or an internship can be chosen here. In total two modules has to be chosen.

Module M0563: Robotics

Courses

Title	Typ	Hrs/wk	CP
Robotics: Modelling and Control (L0168)	Integrated Lecture	4	4
Robotics: Modelling and Control (L1305)	Project-/problem-based Learning	2	2

Module Responsible	Dr. Martin Gomse
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of electrical engineering Broad knowledge of mechanics Fundamentals of control theory
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to describe fundamental properties of robots and solution approaches for multiple problems in robotics.
Skills	Students are able to derive and solve equations of motion for various manipulators. Students can generate trajectories in various coordinate systems. Students can design linear and partially nonlinear controllers for robotic manipulators.
Personal Competence	
Social Competence	Students are able to work goal-oriented in small mixed groups.
Autonomy	Students are able to recognize and improve knowledge deficits independently. With instructor assistance, students are able to evaluate their own knowledge level and define a further course of study.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** Yes / None / Subject theoretical and practical work / Teilnahme an PBL-Einheiten sowie Erreichen des Gesamtziels und der jeweiligen Session-Ziele
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Aeronautics: Core Qualification: Elective Compulsory Mechanical Engineering and Management: Core Qualification: Compulsory Mechatronics: Core Qualification: Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L0168: Robotics: Modelling and Control	
Typ	Integrated Lecture
Hrs/wk	4
CP	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Dr. Martin Gomse
Language	EN
Cycle	WiSe
Content	Fundamental kinematics of rigid body systems Newton-Euler equations for manipulators Trajectory generation Linear and nonlinear control of robots
Literature	Craig, John J.: Introduction to Robotics Mechanics and Control, Third Edition, Prentice Hall. ISBN 0201-54361-3 Spong, Mark W.; Hutchinson, Seth; Vidyasagar, M. : Robot Modeling and Control. WILEY. ISBN 0-471-64990-2

Course L1305: Robotics: Modelling and Control	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Martin Gomse
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0523: Business & Management

Module Responsible	Prof. Matthias Meyer
Admission Requirements	None
Recommended Previous Knowledge	None
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to find their way around selected special areas of management within the scope of business management. • Students are able to explain basic theories, categories, and models in selected special areas of business management. • Students are able to interrelate technical and management knowledge.
Skills	• Students are able to apply basic methods in selected areas of business management. • Students are able to explain and give reasons for decision proposals on practical issues in areas of business management.
Personal Competence	
Social Competence	• Students are able to communicate in small interdisciplinary groups and to jointly develop solutions for complex problems
Autonomy	• Students are capable of acquiring necessary knowledge independently by means of research and preparation of material.
Workload in Hours	Depends on choice of courses
Credit points	6

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

Module M1282: Selected Topics of Mechanical Engineering and Management (Alternative A: 12 CP)

Courses

Title	Typ	Hrs/wk	CP
Fatigue & Damage Tolerance (L0310)	Lecture	2	3
Advanced Research Seminar (L0936)	Seminar	2	2
International Law for Engineers (L1750)	Seminar	2	2
International Law for Engineers (L1749)	Lecture	2	2
Lightweight Design Practical Course (L1258)	Project-/problem-based Learning	3	3
Accounting (L1712)	Lecture	2	2
Accounting (L1713)	Recitation Section (large)	2	2
Structural Mechanics of Fibre Reinforced Composites (L1514)	Lecture	2	3

Module Responsible	Prof. Volker Gollnick
Admission Requirements	None
Recommended Previous Knowledge	see lecture description
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to express their extended knowledge and discuss the connection of different special fields or application areas of Materials, Mechatronics and Product Development and Production • Students are qualified to connect different special fields with each other
Skills	• Students can apply specialized solution strategies and new scientific methods in selected areas • Students are able to transfer learned skills to new and unknown problems and can develop own solution approaches
Personal Competence	
Social Competence	
Autonomy	Students are able to develop their knowledge and skills by autonomous election of courses.
Workload in Hours	Depends on choice of courses
Credit points	12
Assignment for the Following Curricula	Mechanical Engineering and Management: Core Qualification: Elective Compulsory

Course L0310: Fatigue & Damage Tolerance

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. Martin Flamm
Language	EN
Cycle	WiSe
Content	Design principles, fatigue strength, crack initiation and crack growth, damage calculation, counting methods, methods to improve fatigue strength, environmental influences
Literature	Jaap Schijve, Fatigue of Structures and Materials. Kluver Academic Puplisher, Dordrecht, 2001 E. Haibach. Betriebsfestigkeit Verfahren und Daten zur Bauteilberechnung. VDI-Verlag, Düsseldorf, 1989

Course L0936: Advanced Research Seminar	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	10-15 Seiten
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe/SoSe
Content	In this course students will be taught to understand the research process and to interpret scientific papers as a preparation to starting their own scientific initiatives (e.g. Master-Thesis work). Students will work in groups and individually. Each group is expected to work out a presentation summarizing aspects of the research process (including practical examples) and to present and discuss it in class. Further, students will work out a written seminar paper.
Literature	Sekaran and Bougie (2010); Research methods for business: a skill-building approach; Wiley, Chichester Booth, Wayne C. et al. (2008); The craft of research; The University Press of Chicago, Chicago & London Punch, Keith F. (2005); Introduction to social research - quantitative and qualitative approaches; Sage Publications, London Bryman and Bell (2011); Business research methods; Oxford Univ. Press, Oxford Bell, Judith (2010); Doing your research project: a guide for first-time researchers in education, health and social science; Open University Press, Maidenhead

Course L1750: International Law for Engineers	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	10-20 Seiten
Lecturer	Markus A. Meyer-Chory
Language	EN
Cycle	SoSe
Content	• basics and selected legal aspects of international Engineers work - i.e. on contracts, construction, labor, patents, insurance
Literature	As per Stud.IP

Course L1749: International Law for Engineers	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Markus A. Meyer-Chory
Language	EN
Cycle	WiSe
Content	• basics and selected legal aspects of international Engineers work and international laws, such as civil/common law, questions of jurisdiction and courts as well as arbitration and enforcement of titles, etc. • also laws on contracts, construction, labor, patents, companies
Literature	As per Stud.IP.

Course L1258: Lightweight Design Practical Course	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Dieter Krause
Language	DE/EN
Cycle	SoSe
Content	Development of a sandwich structure made of fibre reinforced plastics • getting familiar with fibre reinforced plastics as well as lightweight design • Design of a sandwich structure made of fibre reinforced plastics using finite element analysis (FEA) • Determination of material properties based on sample tests • manufacturing of the structure in the composite lab • Testing of the developed structure • Concept presentation • Self-organised teamwork
Literature	• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, 2005. • Puck, A., „Festigkeitsanalsyse von Faser-Matrix-Laminaten“, Hanser, München, Wien, 1996. • R&G, „Handbuch Faserverbundwerkstoffe“, Waldenbuch, 2009. • VDI 2014 „Entwicklung von Bauteilen aus Faser-Kunststoff-Verbund“ • Ehrenstein, G. W., „Faserverbundkunststoffe“, Hanser, München, 2006. • Klein, B., „Leichtbau-Konstruktion", Vieweg & Sohn, Braunschweig, 1989. • Wiedemann, J., „Leichtbau Band 1: Elemente“, Springer, Berlin, Heidelberg, 1986. • Wiedemann, J., „Leichtbau Band 2: Konstruktion“, Springer, Berlin, Heidelberg, 1986. • Backmann, B.F., „Composite Structures, Design, Safety and Innovation”, Oxford (UK), Elsevier, 2005. • Krause, D., „Leichtbau”, In: Handbuch Konstruktion, Hrsg.: Rieg, F., Steinhilper, R., München, Carl Hanser Verlag, 2012. • Schulte, K., Fiedler, B., „Structure and Properties of Composite Materials”, Hamburg, TUHH - TuTech Innovation GmbH, 2005.

Course L1712: Accounting	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	10-20 Seiten
Lecturer	NN
Language	EN
Cycle	WiSe
Content	**Course objective:** To provide a theoretical and a practical insight into the area of financial and management accounting. **Approach:** Illustration of theoretical concepts combined with case studies and business examples. The exercise is based on the development of a financial business plan for your own business idea. This financial business plan is developed in a team of 3-5 students and presented as well as discussed in the class. I. Introduction to Cost Terms and Concepts II. Standard Costing and Variance Analysis III. Financial Accounting and Reporting (Financial Statement, Income Statement, Cash Flow) IV. Information for Decision Making V. Performance Management: Planning, Budgeting & Forecasting
Literature	**Literature: Business Accounting and Finance 3e** ISBN-13: 9781408018378 / ISBN-10: 1408018373; Catherine Gowthorpe, Oxford Brookes University, 576pp, Published by Cengage Learning, ©2011

Course L1713: Accounting	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	10-20 Seiten
Lecturer	NN
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1514: Structural Mechanics of Fibre Reinforced Composites	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Benedikt Kriegesmann
Language	EN
Cycle	WiSe
Content	Classical laminate theory Rules of mixture Failure mechanisms and criteria of composites Boundary value problems of isotropic and anisotropic shells Stability of composite structures Optimization of laminated composites Modelling composites in FEM Numerical multiscale analysis of textile composites Progressive failure analysis
Literature	• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, aktuelle Auflage. • Wiedemann, J., „Leichtbau Band 1: Elemente“, Springer, Berlin, Heidelberg, , aktuelle Auflage. • Reddy, J.N., „Mechanics of Composite Laminated Plates and Shells”, CRC Publishing, Boca Raton et al., current edition. • Jones, R.M., „Mechanics of Composite Materials“, Scripta Book Co., Washington, current edition. • Timoshenko, S.P., Gere, J.M., „Theory of elastic stability“, McGraw-Hill Book Company, Inc., New York, current edition. • Turvey, G.J., Marshall, I.H., „Buckling and postbuckling of composite plates“, Chapman and Hall, London, current edition. • Herakovich, C.T., „Mechanics of fibrous composites“, John Wiley and Sons, Inc., New York, current edition. • Mittelstedt, C., Becker, W., „Strukturmechanik ebener Laminate”, aktuelle Auflage.

Module M1438: Selected Topics of Mechanical Engineering and Management (Alternative B: 6 CP)

Courses

Title	Typ	Hrs/wk	CP
Fatigue & Damage Tolerance (L0310)	Lecture	2	3
Advanced Research Seminar (L0936)	Seminar	2	2
International Law for Engineers (L1749)	Lecture	2	2
International Law for Engineers (L1750)	Seminar	2	2
Lightweight Design Practical Course (L1258)	Project-/problem-based Learning	3	3
Accounting (L1712)	Lecture	2	2
Accounting (L1713)	Recitation Section (large)	2	2
Structural Mechanics of Fibre Reinforced Composites (L1514)	Lecture	2	3

Module Responsible	Prof. Volker Gollnick
Admission Requirements	None
Recommended Previous Knowledge	see lecture description
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to express their extended knowledge and discuss the connection of different special fields or application areas of Materials, Mechatronics and Product Development and Production • Students are qualified to connect different special fields with each other
Skills	• Students can apply specialized solution strategies and new scientific methods in selected areas • Students are able to transfer learned skills to new and unknown problems and can develop own solution approaches
Personal Competence	
Social Competence	
Autonomy	Students are able to develop their knowledge and skills by autonomous election of courses.
Workload in Hours	Depends on choice of courses
Credit points	6
Assignment for the Following Curricula	Mechanical Engineering and Management: Core Qualification: Elective Compulsory

Course L0310: Fatigue & Damage Tolerance

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	45 min
Lecturer	Dr. Martin Flamm
Language	EN
Cycle	WiSe
Content	Design principles, fatigue strength, crack initiation and crack growth, damage calculation, counting methods, methods to improve fatigue strength, environmental influences
Literature	Jaap Schijve, Fatigue of Structures and Materials. Kluver Academic Puplisher, Dordrecht, 2001 E. Haibach. Betriebsfestigkeit Verfahren und Daten zur Bauteilberechnung. VDI-Verlag, Düsseldorf, 1989

Course L0936: Advanced Research Seminar	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	10-15 Seiten
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe/SoSe
Content	In this course students will be taught to understand the research process and to interpret scientific papers as a preparation to starting their own scientific initiatives (e.g. Master-Thesis work). Students will work in groups and individually. Each group is expected to work out a presentation summarizing aspects of the research process (including practical examples) and to present and discuss it in class. Further, students will work out a written seminar paper.
Literature	Sekaran and Bougie (2010); Research methods for business: a skill-building approach; Wiley, Chichester Booth, Wayne C. et al. (2008); The craft of research; The University Press of Chicago, Chicago & London Punch, Keith F. (2005); Introduction to social research - quantitative and qualitative approaches; Sage Publications, London Bryman and Bell (2011); Business research methods; Oxford Univ. Press, Oxford Bell, Judith (2010); Doing your research project: a guide for first-time researchers in education, health and social science; Open University Press, Maidenhead

Course L1749: International Law for Engineers	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Klausur
Examination duration and scale	90 Minuten
Lecturer	Markus A. Meyer-Chory
Language	EN
Cycle	WiSe
Content	• basics and selected legal aspects of international Engineers work and international laws, such as civil/common law, questions of jurisdiction and courts as well as arbitration and enforcement of titles, etc. • also laws on contracts, construction, labor, patents, companies
Literature	As per Stud.IP.

Course L1750: International Law for Engineers	
Typ	Seminar
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	10-20 Seiten
Lecturer	Markus A. Meyer-Chory
Language	EN
Cycle	SoSe
Content	• basics and selected legal aspects of international Engineers work - i.e. on contracts, construction, labor, patents, insurance
Literature	As per Stud.IP

Course L1258: Lightweight Design Practical Course	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Dieter Krause
Language	DE/EN
Cycle	SoSe
Content	Development of a sandwich structure made of fibre reinforced plastics • getting familiar with fibre reinforced plastics as well as lightweight design • Design of a sandwich structure made of fibre reinforced plastics using finite element analysis (FEA) • Determination of material properties based on sample tests • manufacturing of the structure in the composite lab • Testing of the developed structure • Concept presentation • Self-organised teamwork
Literature	• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, 2005. • Puck, A., „Festigkeitsanalsyse von Faser-Matrix-Laminaten“, Hanser, München, Wien, 1996. • R&G, „Handbuch Faserverbundwerkstoffe“, Waldenbuch, 2009. • VDI 2014 „Entwicklung von Bauteilen aus Faser-Kunststoff-Verbund“ • Ehrenstein, G. W., „Faserverbundkunststoffe“, Hanser, München, 2006. • Klein, B., „Leichtbau-Konstruktion", Vieweg & Sohn, Braunschweig, 1989. • Wiedemann, J., „Leichtbau Band 1: Elemente“, Springer, Berlin, Heidelberg, 1986. • Wiedemann, J., „Leichtbau Band 2: Konstruktion“, Springer, Berlin, Heidelberg, 1986. • Backmann, B.F., „Composite Structures, Design, Safety and Innovation”, Oxford (UK), Elsevier, 2005. • Krause, D., „Leichtbau”, In: Handbuch Konstruktion, Hrsg.: Rieg, F., Steinhilper, R., München, Carl Hanser Verlag, 2012. • Schulte, K., Fiedler, B., „Structure and Properties of Composite Materials”, Hamburg, TUHH - TuTech Innovation GmbH, 2005.

Course L1712: Accounting	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	10-20 Seiten
Lecturer	NN
Language	EN
Cycle	WiSe
Content	**Course objective:** To provide a theoretical and a practical insight into the area of financial and management accounting. **Approach:** Illustration of theoretical concepts combined with case studies and business examples. The exercise is based on the development of a financial business plan for your own business idea. This financial business plan is developed in a team of 3-5 students and presented as well as discussed in the class. I. Introduction to Cost Terms and Concepts II. Standard Costing and Variance Analysis III. Financial Accounting and Reporting (Financial Statement, Income Statement, Cash Flow) IV. Information for Decision Making V. Performance Management: Planning, Budgeting & Forecasting
Literature	**Literature: Business Accounting and Finance 3e** ISBN-13: 9781408018378 / ISBN-10: 1408018373; Catherine Gowthorpe, Oxford Brookes University, 576pp, Published by Cengage Learning, ©2011

Course L1713: Accounting	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Examination Form	Schriftliche Ausarbeitung
Examination duration and scale	10-20 Seiten
Lecturer	NN
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Course L1514: Structural Mechanics of Fibre Reinforced Composites	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Examination Form	Mündliche Prüfung
Examination duration and scale	30 min
Lecturer	Prof. Benedikt Kriegesmann
Language	EN
Cycle	WiSe
Content	Classical laminate theory Rules of mixture Failure mechanisms and criteria of composites Boundary value problems of isotropic and anisotropic shells Stability of composite structures Optimization of laminated composites Modelling composites in FEM Numerical multiscale analysis of textile composites Progressive failure analysis
Literature	• Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, aktuelle Auflage. • Wiedemann, J., „Leichtbau Band 1: Elemente“, Springer, Berlin, Heidelberg, , aktuelle Auflage. • Reddy, J.N., „Mechanics of Composite Laminated Plates and Shells”, CRC Publishing, Boca Raton et al., current edition. • Jones, R.M., „Mechanics of Composite Materials“, Scripta Book Co., Washington, current edition. • Timoshenko, S.P., Gere, J.M., „Theory of elastic stability“, McGraw-Hill Book Company, Inc., New York, current edition. • Turvey, G.J., Marshall, I.H., „Buckling and postbuckling of composite plates“, Chapman and Hall, London, current edition. • Herakovich, C.T., „Mechanics of fibrous composites“, John Wiley and Sons, Inc., New York, current edition. • Mittelstedt, C., Becker, W., „Strukturmechanik ebener Laminate”, aktuelle Auflage.

Module M1292: Marketing and Communication

Courses

Title	Typ	Hrs/wk	CP
Business-to-Business Marketing (L0762)	Lecture	2	2
Case Studies of Marketing and Communication (L1760)	Recitation Section (small)	2	2
Intercultural Management and Communication (L0846)	Lecture	2	2

Module Responsible	Prof. Christian Lüthje
Admission Requirements	None
Recommended Previous Knowledge	No specific knowledge required. Bachelor-level knowledge in business administration with some insights into markting and international management is helpful.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	he students will develop a thorough understanding of the following: • Selling to organizations and industrail buyers • Overview of basic strategic decisions in B2B markets • Relevant theories, methods and tools for operational B2B marketing (Marketing Mix) • Relevant theories for intercultural communication • Communication theories (verbal, non-verbal communication, role of formality, interpretation of cues such as symbols) • The nature of "culture" is and its impact on human interaction • Approaches for managing cultural diversity
Skills	The students will be able to apply this knowledge to: • chosing appropriate cooperation forms when selling to business organizations; • decide about different target markets, ways of market entry, and timingstrategies; • develop appropriate value-propositions to customers; • place, price and communicate industrial products with the help state-of-the-art B2B marketing tools; • interpret symbols, rituals and gestures appropriately in an intercultural contex • managing cultural diversity across the employees of a company • communicating appropriately with customers in different regional markets • apply the theoretical knowledge to business cases or real examples • apply the theoretical knowledge to interpret resarch studies
Personal Competence	
Social Competence	The students will be able to • have fruitful professional discussions; • present and defend the results of their work in a group of students; • work successfully in multi-cultural teams; • communicate and collaborate successfully and respectfully with others, also on an intercultural basis.
Autonomy	The students will be able to acquire knowledge in the specific context of marketing and intercultural communication. This will enable them to make independent and well-founded decisions and to leverage this knowledge to solve new complex problems.
Workload in Hours	Independent Study Time 96, Study Time in Lecture 84
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Written elaboration, excercises, presentation, oral participation
Assignment for the Following Curricula	Global Innovation Management: Core Qualification: Compulsory Mechanical Engineering and Management: Core Qualification: Elective Compulsory

Course L0762: Business-to-Business Marketing	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	WiSe
Content	**Contents** Business-to-business (B2B) markets play an important role in most economies. At the same time, B2B markets differ strongly from consumer goods markets. For example, companies' buying decisions follow different rules than those of consuming individuals. Consequently, marketing mix decisions in B2B markets need to follow the specific circumstances in such markets. The aim of this lecture is to enable students to understand the specifics of marketing in B2B markets. At the beginning, students learn which strategic marketing decisions may be most appropriate in industrial markets. Following that, the lecture will focus more on different options to design marketing mix elements - Pricing, Communication and Distribution - in B2B markets. We extend the student's basic knowhow in marketing and focus on the specific requirements in B2B markets. Topics • The importance, specific characteristics and developments of B2B markets today • Organizational buying behavior and the corporate buying process • B2B marketing strategies regarding modes and time of market entry with focus on innovative industrial products • Types of project-related cooperation in the B2B project business • Specific operational marketing methods in communication (success factors of fares and exhibitions, importance of public relations for B2B markets); pricing (measuring willingness-to-pay via auctions; value-based pricing in industrial markets, bidding models and auctioning); distribution and channel strategies for B2B markets • Marketing in complex value chains: Solving the problem of direct customers' unwillingness to adopt innovative products by directly addressing indirect customers **Knowledge** The students will develop a thorough understanding of: • How organizations and firms buy • How marketing can be performed in complex value chains • Promising market and competitive strategies in B2B markets • Modes of cooperation in B2B markets • Marketing-Mix decisions in B2B marketing (communication, pricing, distribution) **Skills** • analyzing the advantages and disadvantages of different target market, market entry, timing and allocation strategies; • identifying and systematically address relevant partners when selling to business organizations; • developing context-specific market-entry and timing strategies; • making appropriate decisions for the pricing and communication of industrial products; • applying the theoretical knowledge to business cases or real examples **Social Competence** The students will be able to • having fruitful professional discussions; • presenting and defending the results of their work in groupwork; **Self-reliance** • acquiring knowledge in the specific context independently and to map this knowledge onto other new complex problem fields. **Assessment** Written examination & Class participation in interactive elements (presentations, homework)
Literature	Blythe, J., Zimmerman, A. (2005) Business-to-Business Marketing: A global perspective, London, Thomson Monroe, K. B. (2002). Pricing: Making Profitable Decisions, 3rd Edition Morris, M., Pitt, L., Honeycutt, E. (2001), Business-to-Business Marketing, New York, Sage Publishing, 3rd Edition Nagle, T., Hogan, J., Zale, J. (2009), Strategy and Tactics of Pricing, New York, Prentice Hall, 5th Edition

Course L1760: Case Studies of Marketing and Communication	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	WiSe
Content	This course aims at deepening and applying the subjects taught in the lectures "Business-to-Business Marketing" and "Intercultural Communication". Students work on case studies in teams comprising 2-3 people. The case will enable the student teams to analyze problems, to discuss theoretical framworks and scientific results, to evaluate decisions made in companies and/or to develop own ideas for solutions. Each of these cases is related to a specific topic that has been tackled in the other two lectures of this module. The cases can comprise scientific studies or specific company examples (e.g. how company X built up a new salesforce; how company Y designed a successful communication campaign for other countries, how research study Z contributes to the understanding of intercultural differences). The student teams receive material (e.g. scientific articles, press articles) and work with this material to complete presentation documents. The results will be illustrated and discussed in a short presentation.
Literature	Die Materialien werden jedes Semester neu zusammengestellt, um die ausgewählten Fälle aktuell zu halten. Will be newly compiled each semester to keep the cases up-to-date and fresh.

Course L0846: Intercultural Management and Communication	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	WiSe
Content	Globalization of business processes and the revolution in information and communication technologies (ICT) have resulted in distributed workflows across geographic boundaries. These developments as well as increased immigration emanating, for example, as a consequence of a shortage of skilled labour in many industrialized nations, have led to the creation of (virtual) multi-cultural, multi-ethnic teams with diverse cultural backgrounds. Such diversity generally has a positive impact on creativity and innovativeness, as many empirical studies confirm. Nevertheless, varying cultural practices, communication styles, and contextual sensibilities have the potential to disturb or even disrupt collaborative work processes, if left unmanaged. This course focuses on inter-cultural management from both, theoretical as well as practical, points of view to provide a solid fundament to students enabling them to operate successfully in cross-cultural settings. Case studies and guest lecture(s) will be used to provide added practical relevance to the course. In addition, where practicable, student assignments will be used to foster autonomous learning. Some of the main topics covered in this course include: • Understanding “culture” and its impact on human interaction • Verbal and non-verbal communication • High and low context communication • Role of formality and non-formality in communication • Varying interpretations of symbols, rituals & gestures • Managing diversity in domestic settings
Literature	• Bartlett, C.A. / Ghoshal, S. (2002): Managing Across Borders: The Transnational Solution, 2nd edition, Boston • Deresky, H. (2006): International Management: Managing Across Borders and Cultures, 3rd edition, Upper Saddle River • French, R. (2010): Cross-cultural Management in Work Organisations, 2nd edition, London • Hofstede, G. (2003): Culture's Consequences : Comparing Values, Behaviors, Institutions and Organizations across Nations, 2nd edition, Thousand Oaks • Hofstede, G. / Hofstede, G.J. (2006): Cultures and Organizations: Software of the mind, 2nd edition, New York

Module M0524: Non-technical Courses for Master

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

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

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

Module M0809: Computer Aided Design and Computation

Courses

Title	Typ	Hrs/wk	CP
Computer Aided Design and Computation (L0525)	Lecture	2	3
Computer Aided Design and Computation (L0527)	Recitation Section (small)	2	3

Module Responsible	Prof. Claus Emmelmann
Admission Requirements	None
Recommended Previous Knowledge	- Mechanical parts and basic operations of manufacturing techniques - Basic knowledge in mathematics, physics, and statics - 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	- Understanding of the capabilities and limitations of 3D-CAD-Systems, PDM systems, and computer aided simulation Tools - General knowledge of the finite element method in combination with a basic theoretical and methodology basis - Basic understanding of the structural optimizations potential and fields of application
Skills	- Hands-on practice with an exemplary 3D-CAD-system to demonstrate basic modeling techniques as well as interfaces for concurrent finite element analysis
Personal Competence	
Social Competence	
Autonomy	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Mechanical Engineering and Management: Core Qualification: Compulsory

Course L0525: Computer Aided Design and Computation	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Benedikt Kriegesmann, Prof. Claus Emmelmann
Language	EN
Cycle	WiSe
Content	**Part 1: Computer aided design (Prof. Dr.-Ing. D. Krause)** • Introduction to integrated product development • 3D-CAD-systems and CAD-interfaces • Introduction to PDM-systems • Additional computer aided engineering/simulation tools (FEA, DMU, VR) **Part 2: Introduction to the Finite Element Method (Dr.-Ing. S. Lippert)** • General overview on the finite element method • Displacement method • Isoparametric elements • Numerical integration • Applications • Programming of elements (Matlab, hands-on sessions) **Part 3: Structural Optimization Methods (Prof. Dr.-Ing. C. Emmelmann)** • Introduction to structural optimization theory • Fields of application for structural optimization and commercial software tools This module relies heavily on the interconnection of theory and the application of commercial software systems via live demonstrations as well as hands-on sessions in a PC-pool.
Literature	Lee, K.: Principles of CAD / CAM / CAE Systems, Addison Wesley Bathe, K.-J.: Finite element procedures, Prentice Hall Christensen, P.W.; Klarbring, A.: An introduction to structural optimization; Springer

Course L0527: Computer Aided Design and Computation	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Benedikt Kriegesmann, Prof. Claus Emmelmann
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1285: Internship MEM

Courses

Title	Typ	Hrs/wk	CP

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of German language
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to descirbe business structures and processes • They can summarise and present the contents of the project(s) they worked on during the internship
Skills	• Students are able to transfer knowledge and methods learned from the project on other applications • They are able to plan their work and their procedure • During their project, they can make decisions, justify them and based upon these they can draw conclusions on future work
Personal Competence	
Social Competence	• Students know and understand social structures of companies and are able to integrete themselves into these • They can discuss their work with colleagues and respond adequately to critique • They can work in teams, undertake tasks and comply with the time schedule
Autonomy	• Students know their interests, strenghts and weaknesses. Based on this, they can find a suitable position for an internship, apply for it and explain their competences to others.
Workload in Hours	Independent Study Time 180, Study Time in Lecture 0
Credit points	6
Course achievement	None
Examination	Written elaboration (accord. to Internship Regulations)
Examination duration and scale	see internship guidelines
Assignment for the Following Curricula	Mechanical Engineering and Management: Core Qualification: Elective Compulsory

Module M1343: Structure and properties of fibre-polymer-composites

Courses

Title	Typ	Hrs/wk	CP
Structure and properties of fibre-polymer-composites (L1894)	Lecture	2	3
Structure and properties of fibre-polymer-composites (L2614)	Project-/problem-based Learning	2	2
Structure and properties of fibre-polymer-composites (L2613)	Recitation Section (large)	1	1

Module Responsible	Prof. Bodo Fiedler
Admission Requirements	None
Recommended Previous Knowledge	Basics: chemistry / physics / materials science
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can use the knowledge of fiber-reinforced composites (FRP) and its constituents to play (fiber / matrix) and define the necessary testing and analysis. They can explain the complex relationships structure-property relationship and the interactions of chemical structure of the polymers, their processing with the different fiber types, including to explain neighboring contexts (e.g. sustainability, environmental protection).
Skills	Students are capable of • using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials. • approximate sizing using the network theory of the structural elements implement and evaluate. • selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance.
Personal Competence	
Social Competence	Students can • arrive at funded work results in heterogenius groups and document them. • provide appropriate feedback and handle feedback on their own performance constructively.
Autonomy	Students are able to - assess their own strengths and weaknesses. - assess their own state of learning in specific terms and to define further work steps on this basis. - assess possible consequences of their professional activity.
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	Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Aeronautics: Core Qualification: Elective Compulsory Materials Science and Engineering: Specialisation Engineering Materials: Elective Compulsory Materials Science: Specialisation Engineering Materials: Elective Compulsory Mechanical Engineering and Management: Core Qualification: Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Compulsory Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

Course L1894: Structure and properties of fibre-polymer-composites	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bodo Fiedler
Language	EN
Cycle	SoSe
Content	- Microstructure and properties of the matrix and reinforcing materials and their interaction - Development of composite materials - Mechanical and physical properties - Mechanics of Composite Materials - Laminate theory - Test methods - Non destructive testing - Failure mechanisms - Theoretical models for the prediction of properties - Application
Literature	Hall, Clyne: Introduction to Composite materials, Cambridge University Press Daniel, Ishai: Engineering Mechanics of Composites Materials, Oxford University Press Mallick: Fibre-Reinforced Composites, Marcel Deckker, New York

Course L2614: Structure and properties of fibre-polymer-composites	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Bodo Fiedler
Language	DE/EN
Cycle	SoSe
Content	The students receive the assignment in the form of a material design for test bodies made of fibre composites. Technical and normative requirements are listed in the assignment, all other required information comes from the lectures and exercises or the respective documents (electronically and in conversation). The procedure is specified in a milestone plan and enables the students to plan subtasks and thus work continuously. At the end of the project, different test specimens were tested in tensile or bending tests. In the individual project meetings, the conception (discussion of requirements and risks) is scrutinised. The calculations are analysed, the production methods are evaluated and determined. Materials are selected and the test specimens are manufactured according to standards. The quality and mechanical properties are checked and classified. At the end, a final report is prepared and the results are presented to all participants in the form of a presentation and discussed. Translated with www.DeepL.com/Translator (free version)
Literature	Hall, Clyne: Introduction to Composite materials, Cambridge University Press Daniel, Ishai: Engineering Mechanics of Composites Materials, Oxford University Press Mallick: Fibre-Reinforced Composites, Marcel Deckker, New York

Course L2613: Structure and properties of fibre-polymer-composites	
Typ	Recitation Section (large)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Bodo Fiedler
Language	EN
Cycle	SoSe
Content	The contents of the lecture are repeated and deepened using practical examples. Calculations are carried out together or individually, and the results are discussed critically.
Literature	Hall, Clyne: Introduction to Composite materials, Cambridge University Press Daniel, Ishai: Engineering Mechanics of Composites Materials, Oxford University Press Mallick: Fibre-Reinforced Composites, Marcel Deckker, New York

Module M1283: Research Project IMPMEM

Courses

Title	Typ	Hrs/wk	CP

Module Responsible	Dozenten des Studiengangs
Admission Requirements	None
Recommended Previous Knowledge	Subjects of the Master program and the chosen specialisation.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can explain the project as well as their autonomously gained knowledge and relate it to current issues of their field of study. • They can explain the basic scientific methods they have worked with.
Skills	The students are able to autonomously solve a limited scientific task under the guidance of an experienced researcher. They can justify and explain their approach for problem solving; they can draw conclusions from their results, and then can find new ways and methods for their work. Students are capable of comparing and assessing alternative approaches with their own with regard to given criteria.
Personal Competence	
Social Competence	The students are able to condense the relevance and the structure of the project work, the work procedure and the sub-problems for the presentation and discussion in front of a bigger group. They can lead the discussion and give a feedback on the project to their peers and supervisors.
Autonomy	The students are capable of independently planning and documenting the work steps and procedures while considering the given deadlines. This includes the ability to accurately procure the newest scientific information. Furthermore, they can obtain feedback from experts with regard to the progress of the work, and to accomplish results on the state of the art in science and technology.
Workload in Hours	Independent Study Time 360, Study Time in Lecture 0
Credit points	12
Course achievement	None
Examination	Study work
Examination duration and scale	see FSPO
Assignment for the Following Curricula	Mechanical Engineering and Management: Core Qualification: Compulsory

Specialization Management

Graduates of the Management specialization learn to use their knowledge in management and business topics for the planning of production processes and projects. Furthermore they have extended knowledge in special topics, such as human resources, entrepreneurship or logistics. Graduates are able to evaluate the necessary business and financial key figures and to make decisions based on these. They are able to put their theoretical knowledge into practice and to analyze complex questions in business administration. They learn diverse methods and techniques of management and business administration and are able to use them successful for different tasks.

Students have to choose the Management specialization. Solely students of the Northern Institute of Technology have to choose two engineering specializations.

Module M0814: Technology Management

Courses

Title	Typ	Hrs/wk	CP
Technology Management (L0849)	Lecture	3	3
Technology Management Seminar (L0850)	Project-/problem-based Learning	2	3

Module Responsible	Prof. Cornelius Herstatt
Admission Requirements	None
Recommended Previous Knowledge	Bachelor knowledge in business management
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	

Knowledge	Students will gain deep insights into:
	• International R&D-Management
	• Technology Timing Strategies
	  ◦ Technology Strategies and Lifecycle Management (I/II)
	  ◦ Technology Intelligence and Planning
	• Technology Portfolio Management
	  ◦ Technology Portfolio Methodology
	  ◦ Technology Acquisition and Exploitation
	  ◦ IP Management
	• Organizing Technology Development
	  ◦ Technology Organization & Management
	  ◦ Technology Funding & Controlling

Skills	The course aims to: • Develop an understanding of the importance of Technology Management - on a national as well as international level • Equip students with an understanding of important elements of Technology Management (strategic, operational, organizational and process-related aspects) • Foster a strategic orientation to problem-solving within the innovation process as well as Technology Management and its importance for corporate strategy • Clarify activities of Technology Management (e.g. technology sourcing, maintenance and exploitation) • Strengthen essential communication skills and a basic understanding of managerial, organizational and financial issues concerning Technology-, Innovation- and R&D-management. Further topics to be discussed include: • Basic concepts, models and tools, relevant to the management of technology, R&D and innovation • Innovation as a process (steps, activities and results)
Personal Competence	
Social Competence	• Interact within a team • Raise awareness for globabl issues
Autonomy	• Gain access to knowledge sources • Discuss recent research debates in the context of Technology and Innovation Management • Develop presentation skills • Discussion of international cases in R&D-Management
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 minutes
Assignment for the Following Curricula	Global Innovation Management: Core Qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: 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: Compulsory

Course L0849: Technology Management	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	The role of technology for the competitive advantage of the firm and industries; Basic concepts, models and tools for the management of technology; managerial decision making regarding the identification, selection and protection of technology (make or buy, keep or sell, current and future technologies). Theories, practical examples (cases), lectures, interactive sessions and group study. This lecture is part of the Module Technology Management and can not separately choosen.
Literature	Leiblein, M./Ziedonis, A.: Technology Strategy and Inoovation Management, Elgar Research Collection, Northhampton (MA) 2011

Course L0850: Technology Management Seminar	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	Beside the written exam at the end of the module, students have to give one presentation (RE) on a research paper and two presentations as part of a group discussion (GD) in the seminar in order to pass. With these presentations it is possible to gain a bonus of max. 20% for the exam. However, the bonus is only valid if the exam is passed without the bonus.
Literature	see lecture Technology Management.

Module M0978: Sustainable Mobility of Goods and Logistics Systems

Courses

Title	Typ	Hrs/wk	CP
International Logistics and Transport Systems (L1168)	Project-/problem-based Learning	3	4
Sustainable Mobility of Goods, Logistics, Traffic (L1165)	Lecture	2	2

Module Responsible	Prof. Heike Flämig
Admission Requirements	None
Recommended Previous Knowledge	• Introduction to Logistics and Mobility • Foundations of Management • Legal Foundations of Transportation and Logistics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to... • give definitions of system theory, (international) transport chains and logistics in the context of supply chain management • explain trends and strategies for mobility of goods and logistics • describe elements of integrated and multi-modal transport chains and their advantages and disadvantages • deduce impacts of management decisions on logistics system and traffic system and explain how stakeholders influence them • explain the correlations between economy and logistics systems, mobility of goods, space-time-structures and the traffic system as well as ecology and politics
Skills	Students are able to... • Design intermodal transport chains and logistic concepts • apply the commodity chain theory and case study analysis • evaluate different international transport chains • cope with differences in cultures that influence international transport chains
Personal Competence	
Social Competence	Students are able to... • develop a feeling of social responsibility for their future jobs • give constructive feedback to others about their presentation skills • plan and execute teamwork tasks
Autonomy	Students are able to improve presentation skills by feedback of others
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6

Course achievement

Compulsory	Bonus	Form	Description
Yes	None	Participation in excursions	
Yes	None	Excercises	

Examination	Written exam
Examination duration and scale	written exam (60 minutes), exercises in groups (min. 80% attendance), one-day excursion with short presentations
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory

Course L1168: International Logistics and Transport Systems	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Heike Flämig
Language	EN
Cycle	SoSe
Content	The problem-oriented-learning lecture consists of case studies and complex problems concerning the systemic characteristics of different modes of transport as well as the organization and realization of transport chains. Students get to know specific issues from practice of logistics and mobility of goods and work out recommondations for solutions.
Literature	David, Pierre A.; Stewart, Richard D.: International Logistics: The Management of International Trade Operations, 3rd Edition, Mason, 2010 Schieck, Arno: Internationale Logistik: Objekte, Prozesse und Infrastrukturen grenzüberschreitender Güterströme, München, 2009

Course L1165: Sustainable Mobility of Goods, Logistics, Traffic	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Heike Flämig
Language	EN
Cycle	SoSe
Content	The intention of this lecture is to provide a general system analysis-based overview of how transportation chains emerge and how they are developed. The respective advantages and disadvantages of different international transportation chains of goods are to be pointed out from a micro- and a macroeconomic point of view. The effects on the traffic system as well as the ecological and social consequences of a spatial devision of economical activities are to be discussed. The overview of current international transportation chains is carried out on the basis of concrete material- and appendant information flows. Established transportation chains and some of their individual elements are to become transparent to the students by a number of practical examples. 1. A conceptual systems model 2. Elements of integrated and multi-modal transportation chains 3. interaction of transport and traffic, demand and supply on different layers of the transport system 4. Global Issues in Supply Chain Management 5. Global Players and networks 6. Logistics and corporate social responsibility (CSR) 7. Methods and data for assessment of international transport chains 8. Influence of cultural aspects on international transport chains 9. New solutions using different focuses of the transport and logstics system
Literature	David, Pierre A.; Stewart, Richard D.: International Logistics: The Management of International Trade Operations, 3rd Edition, Mason, 2010 Schieck, Arno: Internationale Logistik: Objekte, Prozesse und Infrastrukturen grenzüberschreitender Güterströme, München, 2009 BLOECH, J., IHDE, G. B. (1997) Vahlens Großes Logistiklexikon, München, Verlag C.H. Beck IHDE, G. B. (1991) Transport, Verkehr, Logistik, München, Verlag Franz Vahlen, 2. völlig überarbeitete und erweiterte Auflage NUHN, H., HESSE, M. (2006) Verkehrsgeographie, Paderborn, München, Wien, Zürich, Verlage Ferdinand Schöningh PFOHL, H.-C. (2000) Logistiksysteme - Betriebswirtschaftliche Grundlagen, Berlin, Heidelberg, New York, Springer-Verlag, 6. Auflage

Module M1034: Technology Entrepreneuship

Courses

Title	Typ	Hrs/wk	CP
Creation of Business Opportunities (L1280)	Project-/problem-based Learning	3	3
Entrepreneurship (L1279)	Lecture	2	3

Module Responsible	Prof. Christoph Ihl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in business economics obtained in the compulsory modules as well as an interest in new technologies and the pursuit of new business opportunities either in corporate or startup contexts.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Wissen (subject-related knowledge and understanding): • develop a working knowledge and understanding of the entrepreneurial perspective • understand the difference between a good idea and scalable business opportunity • understand the process of taking a technology idea and finding a high-potential commercial opportunity • understand the components of business models • understand the components of business opportunity assessment and business plans
Skills	• Fertigkeiten (subject-related skills): ◦ identify and define business opportunities ◦ assess and validate entrepreneurial opportunities ◦ create and verify a business model of how to sell and market an entrepreneurial opportunity ◦ formulate and test business model assumptions and hypotheses ◦ conduct customer and expert interviews regarding business opportunities ◦ prepare business opportunity assessment ◦ create and verify a plan for gathering resources such as talent and capital ◦ pitch a business opportunity to your classmates and the teaching team
Personal Competence	
Social Competence	Sozialkompetenz (Social Competence): • team work • communication and presentation • give and take critical comments • engaging in fruitful discussions
Autonomy	Selbständigkeit (Autonomy): • autonomous work and time management • project management • analytical skills
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Three presentations on the respective project status
Assignment for the Following Curricula	Global Technology and Innovation Management & Entrepreneurship: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Logistics, Infrastructure and Mobility: Core Qualification: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory

Course L1280: Creation of Business Opportunities	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Christoph Ihl
Language	EN
Cycle	SoSe
Content	Important note: This course is part of an 6 ECTS module consisting of two courses "Entrepreneurship" & "Creation of Business Opportunities", which have to be taken together in one semester. Startups are temporary, team-based organizations, which can form both within and outside of established companies, to pursue one central objective: taking a new venture idea to market by designing a business model that can be scaled to a full-grown company. In this course, students will form startup teams around self-selected ideas and run through the process just like real startups would do in the first three months of intensive work. Startup Engineering takes an incremental and iterative approach, in that it favors variety and alternatives over one detailed, linear five-year business plan to reach steady state operations. From a problem solving and systems thinking perspective, student teams create different possible versions of a new venture and alternative hypotheses about value creation for customers and value capture vis-à-vis competitors. We will draw on recent scientific findings about international success factors of new venture design. To test critical hypotheses early on, student teams engage in scientific, evidence-based, experimental trial-and-error learning process that measures real progress. Upon completion of this course, students will be able to: · Apply a modern innovation toolkit relevant in both the corporate & startup world · Analyze given business opportunities in terms of its constituent elements · Design new business models by gathering and combining relevant ideas, facts and information · Evaluate business opportunities and derive judgment about next steps & decisions Course language is English, but participants can decide to give their graded presentations in German. Students are invited to apply to this course module already with a startup idea and/ or team, but this is not a requirement! We will form teams and ideas in the beginning of the course. Class meetings have alternate intervals of lecture inputs, teamwork, mentoring, and peer feedback. Attendance is mandatory for at least 80% of class time due to large proportion of teamwork sessions. Student teams give three presentations and submit them with backup analyses. Grading scheme: · Startup discovery presentation after 5 weeks: 30% · Startup validation presentation after 10 weeks: 30% · Final startup pitches after 13 weeks: 40%
Literature	• Blank, S. & Dorf, B. (2012). The startup owner's manual. • Gans, J. & Stern, S. (2016). Entrepreneurial Strategy. • Osterwalder, A. & Yves, P. (2010). Business model generation. • Maurya, A. (2012). Running lean: Iterate from plan A to a plan that works. • Maurya, A. (2016). Scaling lean: Mastering the Key Metrics for Startup Growth. • Wilcox, J. (2016). FOCUS Framework: How to Find Product-Market Fit.

Course L1279: Entrepreneurship	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christoph Ihl
Language	EN
Cycle	SoSe
Content	Important note: This course is part of an 6 ECTS module consisting of two courses "Entrepreneurship" & "Creation of Business Opportunities", which have to be taken together in one semester. Startups are temporary, team-based organizations, which can form both within and outside of established companies, to pursue one central objective: taking a new venture idea to market by designing a business model that can be scaled to a full-grown company. In this course, students will form startup teams around self-selected ideas and run through the process just like real startups would do in the first three months of intensive work. Startup Engineering takes an incremental and iterative approach, in that it favors variety and alternatives over one detailed, linear five-year business plan to reach steady state operations. From a problem solving and systems thinking perspective, student teams create different possible versions of a new venture and alternative hypotheses about value creation for customers and value capture vis-à-vis competitors. We will draw on recent scientific findings about international success factors of new venture design. To test critical hypotheses early on, student teams engage in scientific, evidence-based, experimental trial-and-error learning process that measures real progress. Upon completion of this course, students will be able to: · Apply a modern innovation toolkit relevant in both the corporate & startup world · Analyze given business opportunities in terms of its constituent elements · Design new business models by gathering and combining relevant ideas, facts and information · Evaluate business opportunities and derive judgment about next steps & decisions Course language is English, but participants can decide to give their graded presentations in German. Students are invited to apply to this course module already with a startup idea and/ or team, but this is not a requirement! We will form teams and ideas in the beginning of the course. Class meetings have alternate intervals of lecture inputs, teamwork, mentoring, and peer feedback. Attendance is mandatory for at least 80% of class time due to large proportion of teamwork sessions. Student teams give three presentations and submit them with backup analyses. Grading scheme: · Startup discovery presentation after 5 weeks: 30% · Startup validation presentation after 10 weeks: 30% · Final startup pitches after 13 weeks: 40%
Literature	• Blank, S. & Dorf, B. (2012). The startup owner's manual. • Gans, J. & Stern, S. (2016). Entrepreneurial Strategy. • Osterwalder, A. & Yves, P. (2010). Business model generation. • Maurya, A. (2012). Running lean: Iterate from plan A to a plan that works. • Maurya, A. (2016). Scaling lean: Mastering the Key Metrics for Startup Growth. • Wilcox, J. (2016). FOCUS Framework: How to Find Product-Market Fit.

Module M1255: International Production Management and Enterprise Resource Planning: CERMEDES AG

Courses

Title	Typ	Hrs/wk	CP
International Production Management and Enterprise Resource Planning: CERMEDES AG (L1232)	Seminar	4	6

Module Responsible	Prof. Christian Ringle
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in business administration.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to... • describe an internationally active company; • describe complex and interrelated business processes along the supply chain; • present important aspects of the project management of enterprise resource planning software implementations; • name rules and processes for the implementation of business processes in SAP; • explain the functioning and use of enterprise resource planning software along the supply chain; • conduct business processes in SAP on their own; • present the integrative role of enterprise resource planning systems.
Skills	The students are able to... • map the design of business processes along the supply chain of a firm; • implement business processes in an enterprise resource planning software; • use an internationally used enterprise resource planning software in a daily routine; • critically evaluate the enterprise resource planning software along the theoretical requirements for optimally designing a business process.
Personal Competence	
Social Competence	The students are able to... • direct fruitful and professional discussions; • work in teams on exercises; • present and defend results of their work; • communicate and collaborate successfully and respectfully with others in teams.
Autonomy	The students will be able to acquire knowledge in a specific context independently and to map this knowledge onto other new complex problem fields.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	Compulsory / Bonus / Form / Description Yes / None / Written elaboration Yes / None / Presentation
Examination	Subject theoretical and practical work
Examination duration and scale	Case studies, Mini-Challenges, Presentations
Assignment for the Following Curricula	Mechanical Engineering and Management: Specialisation Management: Elective Compulsory

Course L1232: International Production Management and Enterprise Resource Planning: CERMEDES AG	
Typ	Seminar
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Christian Ringle
Language	EN
Cycle	SoSe
Content	The course involves two main parts: During the first part of the course, participants are provided with insights into the market for ERP-Software and are provided with knowledge on how ERP-implementation projects proceed and how these projects should ideally be managed from a theoretical and practical perspective. In addition, participants are provided with an understanding of business functions and processes by means of visiting the TUHH model factory. In the model factory, participants and are solving special business cases on the basis of group-specific tasks. Finally, participants are introduced into the basic functioning of ERP-Software referring to the most common system (SAP). Participants gain a basic understanding of implementing organizational data, master data and processes into the system. During the second phase of this course, the students work independently in groups on deepening challenges, which conceptually build up on the executed case studies from phase one. Using the knowledge from phase one, the students are able to transfer the theoretical knowledge on the practical execution of the challes in SAP. The results of the group work will be presented in phase two.
Literature	Participants will be provided with a course handout in the form of ppt.-slides which can be downloaded in advance. Further literature references regarding the theoretical concepts are not provided (as this is part of the challenge in writing the thesis); literature references with regard to the ERP-System used are as follows: • Agrawal, A. (2009): Customizing Materials Management Processes in SAP ERP Operations, Galileo Press: Boston. • Arif, N./Tauseef, S. (2010): Integrating SAP ERP Financials, Galileo Press: Boston. • Chudy, M./Castedo, L. (2015): Sales and Distribution in SAP ERP - Practical Guide, Galileo Press: Boston. • Dickersback, J. T./Keller, G. (2010): Production Planning and Control with SAP ERP, 2e, Galileo Press: Boston. • Franz, M. (2014): Project Management with SAP Project System, 4e, Galileo Press: Boston. • Hoppe, M./Gulyassy, F. (2009): Materials Planning with SAP, Galileo Press: Boston. • Veeriah, N. (2011): Customizing Financial Accounting in SAP, Galileo Press: Boston. • Veeriah, N. (2011): Financial Accounting in SAP, Galileo Press: Boston.

Module M1263: Quantitative Research Methods

Courses

Title	Typ	Hrs/wk	CP
Quantitative Research Methods (L1714)	Project Seminar	3	6

Module Responsible	Prof. Christian Ringle
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in business administration.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will be able to... • describe complex and interrelated constructs in the fields of marketing, management of organizations, strategic and human resource management; • discuss underlying theories of research models; • explain strategies of research problem analysis; • describe the functioning and use of quantitative research methods; • discuss strengths and weaknesses of quantitative research methods.
Skills	The students will be able to... • deal with complex empirical problems; • collect empirical data, apply multivariate techniques to the data collected using standard software, and critically evaluate and interpret results gained; • work with common statistical software programs (like R, Smart PLS and SPSS); • address research questions with quantitative research methods.
Personal Competence	
Social Competence	The students will be able to... • have fruitful professional discussions; • present and defend the results of their work; • communicate and collaborate successfully and respectfully with others in teams.
Autonomy	The students will be able to... • acquire knowledge in a specific context independently and to map this knowledge onto other new complex problem fields, • read and understand statistical literature.
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	30 pages; 5 months
Assignment for the Following Curricula	Mechanical Engineering and Management: Specialisation Management: Elective Compulsory

Course L1714: Quantitative Research Methods	
Typ	Project Seminar
Hrs/wk	3
CP	6
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42
Lecturer	Prof. Christian Ringle
Language	EN
Cycle	WiSe/SoSe
Content	Participants will understand the use, requirements, advantages and disadvantages of quantitative methods. Examples illustrate the application of quantitative methods and their use to address business related problems. The course involves three parts: • The first part of the course focuses on an introduction of quantitative research methods, • The second part of the course involves working on a seminar thesis. Participants are in teams invited to describe selected quantitative research methods and to address simple research questions with the described method. Students are expected to write a short (empirical) paper that applies methods learned in this course to a research question of their choice, • The third part is the final presentations of the results from the group work. Participants will present their own small research projects and discuss the results in the plenum. Participants are invited to join the discussions as a part of the final grade.
Literature	Participants will be provided with a course handout in the form of ppt.-slides which can be downloaded in advance. In the course, the participants will obtain a specific list of relevant literature. Some generally recommended are: • Dalgaard, P. (2008). Introductory statistics with R. Springer Science & Business Media. • Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). Multivariate data analysis (Vol. 6). Upper Saddle River, NJ: Pearson Prentice Hall. • Hair Jr, J. F., Hult, G. T. M., Ringle, C., & Sarstedt, M. (2013). A primer on partial least squares structural equation modeling (PLS-SEM). Sage Publications.

Module M0750: Economics

Courses

Title	Typ	Hrs/wk	CP
International Economics (L0700)	Lecture	2	2
Main Theoretical and Political Concepts (L0641)	Lecture	2	2
Economics (L2714)	Project-/problem-based Learning	1	2

Module Responsible
Prof. Timo Heinrich

Admission Requirements
None

Recommended Previous Knowledge
Basic knowledge of economics is expected.

The prior knowledge in the field of economics required for successful completion of this module is imparted as an e-learning offering. Students will receive access and further information on the associated online learning module when they enroll.

By taking an associated online test, the student can acquire points that are added to the result of the final examination of the Economics module.

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

Professional Competence

Knowledge
The students know

- the most important principles of individual decision making in a national and international context,
- different market structures,
- types of market failure,
- the functioning of a single economy (including money market, financial and goods markets, labor market),
- the difference between and the interdependence of short and long run equilibria,
- the significance of expectations on the effects of economic policy,
- the various links between economies and
- different economic policies and their effects on the economy.

Skills
The students are able to model analytically or graphically

- the most important principles of individual decision making in a national and international context,
- the market results of different market structures and market failure,
- the welfare effects of the market results,
- the functioning of an economy (including money market, financial and goods markets, labor market),
- links between economies and
- the effects of economic policies.

Personal Competence

Social Competence
The students are able

- to anticipate expectations and decisions of individuals or groups of individuals. These may be inside or outside of the own firm,
- to take these decisions into account while deciding themselves and
- to understand the behavior of markets and to assess the opportunities and risks with respect to the own business activities.

Autonomy
With the methods taught the students will be able

- to analyze empirical phenomena in single economies and the world economy and to reconcile them with the studied theoretical concepts and
- to design, analyze and evaluate micro- and macroeconomic policies against the background of different models.

Workload in Hours
Independent Study Time 110, Study Time in Lecture 70

Credit points
6

Course achievement

Compulsory	Bonus	Form	Description
Yes	5 %	Excercises	
No	15 %	Presentation	

Examination
Written exam

Examination duration and scale
60 min

Assignment for the Following Curricula
International Management and Engineering: Core Qualification: Compulsory
Logistics, Infrastructure and Mobility: Core Qualification: Elective Compulsory
Mechanical Engineering and Management: Specialisation Management: Elective Compulsory

Course L0700: International Economics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Timo Heinrich
Language	EN
Cycle	SoSe

Content	• International Trade Theory and Policy:
	  ◦ Comparative Advantage - the Ricardian Model
	  ◦ The Heckscher-Ohlin Model
	  ◦ The Standard Trade Model
	  ◦ Intrasectoral Trade
	  ◦ International Trade Policy

Literature	• Mankiw/Taylor: Economics, Cengage, 5th ed., 2020 • Krugman/Obstfeld/Mehlitz: International Economics, Pearson, 11th ed. 2018 • The CORE Team: The Economy: Economics for a Changing World, Oxford University Press, 2017

Course L0641: Main Theoretical and Political Concepts	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Timo Heinrich
Language	EN
Cycle	SoSe

Content	• Introduction: Ten Principles of Economics
	• Microeconomics:
	  ◦ Theory of the Household
	  ◦ Theory of the Firm
	  ◦ Competitive Markets in Equilibrium
	  ◦ Market Failure: Monopoly and External Effects
	  ◦ Government Policies
	• Macroeconomics:
	  ◦ A Nation’s Real Income and Production
	  ◦ The Real Economy in the Long Run: Capital and Labour Market
	  ◦ Money and Prices in the Long Run
	  ◦ Aggregate Demand and Supply: Short-Run Economic Fluctuations
	  ◦ Monetary and Fiscal Policy in the Short and the Long Run

Literature	• Mankiw/Taylor: Economics, Cengage, 5th ed., 2020 • Pindyck/Rubinfeld: Microeconomics, Prentice Hall International, 7th ed. 2010 • The CORE Team: The Economy: Economics for a Changing World, Oxford University Press, 2017

Course L2714: Economics	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Timo Heinrich
Language	EN
Cycle	SoSe
Content	Students work in teams on in-depth questions related to the contents of the lectures and present the results.
Literature	• Mankiw/Taylor: Economics, Cengage, 5th ed., 2020 • Krugman/Obstfeld/Mehlitz: International Economics, Pearson, 11th ed. 2018 • Pindyck/Rubinfeld, Microceconomics, Pearson, 9th ed., 2018 • The CORE Team: The Economy: Economics for a Changing World, Oxford University Press, 2017

Module M0855: Marketing (Sales and Services / Innovation Marketing)

Courses

Title	Typ	Hrs/wk	CP
Marketing of Innovations (L2009)	Lecture	4	4
PBL Marketing of Innovations (L0862)	Project-/problem-based Learning	1	2

Module Responsible	Prof. Christian Lüthje
Admission Requirements	None
Recommended Previous Knowledge	• Module International Business • Basic understanding of business administration principles (strategic planning, decision theory, project management, international business) • Bachelor-level Marketing Knowledge (Marketing Instruments, Market and Competitor Strategies, Basics of Buying Behavior) • Unerstanding the differences beweetn B2B and B2C marketing • Understanding of the importance of managing innovation in global industrial markets • Good English proficiency; presentation skills
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will have gained a deep understanding of • Specific characteristics in the marketing of innovative poroducts and services • Approaches for analyzing the current market situation and the future market development • The gathering of information about future customer needs and requirements • Concepts and approaches to integrate lead users and their needs into product and service development processes • Approaches and tools for ensuring customer-orientation in the development of new products and innovative services • Marketing mix elements that take into consideration the specific requirements and challenges of innovative products and services • Pricing methods for new products and services • The organization of complex sales forces and personal selling • Communication concepts and instruments for new products and services
Skills	Based on the acquired knowledge students will be able to: • Design and to evaluate decisions regarding marketing and innovation strategies • Analyze markets by applying market and technology portfolios • Conduct forecasts and develop compelling scenarios as a basis for strategic planning • Translate customer needs into concepts, prototypes and marketable offers and successfully apply advanced methods for customer-oriented product and service development • Use adequate methods to foster efficient diffusion of innovative products and services • Choose suitable pricing strategies and communication activities for innovations • Make strategic sales decisions for products and services (i.e. selection of sales channels) • Apply methods of sales force management (i.e. customer value analysis)
Personal Competence	
Social Competence	The students will be able to • have fruitful discussions and exchange arguments • develop original results in a group • present results in a clear and concise way • carry out respectful team work
Autonomy	The students will be able to • Acquire knowledge independently in the specific context and to map this knowledge on other new complex problem fields. • Consider proposed business actions in the field of marketing and reflect on them.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	Written elaboration, excercises, presentation, oral participation
Assignment for the Following Curricula	Global Technology and Innovation Management & Entrepreneurship: Core Qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: 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: Compulsory

Course L2009: Marketing of Innovations	
Typ	Lecture
Hrs/wk	4
CP	4
Workload in Hours	Independent Study Time 64, Study Time in Lecture 56
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
Content	I. Introduction • Innovation and service marketing (importance of innovative products and services, model, objectives and examples of innovation marketing, characteristics of services, challenges of service marketing) II. Methods and approaches of strategic marketing planning • patterns of industrial development, patent and technology portfolios III. Strategic foresight and scenario analysis • objectives and challenges of strategic foresight, scenario analysis, Delphi method IV. User innovations • Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis V. Customer-oriented Product and Service Engineering • Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting VII. Pricing • Basics of Pricing, Value-based pricing, Pricing models VIII. Sales Management • Basics of Sales Management, Assessing Customer Value, Planning Customer Visits IX. Communications • Diffusion of Innovations, Communication Objectives, Communication Instruments
Literature	**Mohr, J., Sengupta, S., Slater, S. (2014). Marketing of high-technology products and innovations, third edition, Pearson education. ISBN-10: 1292040335 . Chapter 6 (188-210), Chapter 7 (227-256), Chapter 10 (352-365), Chapter 12 (419-426).** Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw Hill, Boston et al., 2008 Christensen, C. M. (1997). Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Harvard Business Press, Chapter 1: How can great firms fail?,pp. 3-24. Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4th edition, Boston et al., McGraw Hill Tidd; J. & Hull, Frank M. (Editors) (2007) Service Innovation, London Von Hippel, E.(2005). Democratizing Innovation, Cambridge: MIT Press

Course L0862: PBL Marketing of Innovations	
Typ	Project-/problem-based Learning
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Christian Lüthje
Language	EN
Cycle	SoSe
Content	This PBL course is seggregated into two afternoon sessions. This cours aims at enhancing the students' practical skills in (1) forecasting the future development of markets and (2) making appropriate market-related decisions (particularly segmentation, managing the marketing mix). The students will be prompted to use the knowledge gathered in the lecture of this module and will be invited to (1) Conduct a scenario analysis for an innovative product category and (2) Engage in decision making wtihin a market simulation game.
Literature	

Module M1035: Entrepreneurial Finance

Courses

Title	Typ	Hrs/wk	CP
Entrepreneurial Finance: Case Studies (L1282)	Seminar	3	4
Entrepreneurial Finance: Lecture (L1281)	Lecture	2	2

Module Responsible	Prof. Christoph Ihl
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in business economics and finance obtained in the compulsory modules and participation in the module "Technology Entrepreneurship" is highly recommended.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Wissen (subject-related knowledge and understanding): • understand the structure of a financial plan for a new venture • understand the procedures, pros and cons of different valuation methods • understand the design of financial contracts and term sheets • understand the interests of venture capital funds • understand the pros and cons of different growth and exit options
Skills	Fertigkeiten (subject-related skills): • prepare a financial plan for a new venture • value a new venture in financial terms • apply different valuation methods • evaluate the attractiveness of financial contracts • design VC term sheets • design employee contracts in terms of financial compensation • design financial contracts and conduct financial negotiations • assess and justify possible growth and exit options
Personal Competence	
Social Competence	Sozialkompetenz (Social Competence): • team work • communication and presentation • give and take critical comments • engaging in fruitful discussions
Autonomy	Selbständigkeit (Autonomy): • autonomous work and time management • project management • analytical skills
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** Yes / 20 % / Group discussion
Examination	Subject theoretical and practical work
Examination duration and scale	Presentations and case study work
Assignment for the Following Curricula	Global Innovation Management: Core Qualification: Elective Compulsory Global Technology and Innovation Management & Entrepreneurship: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory

Course L1282: Entrepreneurial Finance: Case Studies	
Typ	Seminar
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Christoph Ihl
Language	EN
Cycle	WiSe
Content	Entrepreneurial finance is at the center of a clash of two very distant worlds: that of entrepreneurship and that of finance. Finance is disciplined, based on numbers and logical thinking and looking for proven track records. Entrepreneurship is messy, based on intuition and experimentation and treading off the beaten track. Entrepreneurial finance is the provision of funding to young, innovative, growth-oriented companies. Entrepreneurial companies are young, typically less than ten years old, and introduce innovative products or business models. The younger are called “startups,” and are typically less than five years old. There is a variety of investors who can finance entrepreneurial companies: family and friends, business angels, accelerators and incubators, crowdfunding platforms, venture capital firms, corporate investors, etc. The course provides a thorough understanding of what motivates them, of the way they invest, and of what support they can provide to a company at what stage in the fundraising cycle. The course addresses the following key questions: How much money can and should be raised? When should it be raised and from whom? What is a reasonable valuation of the company? How should funding, employment contracts and exit decisions be structured? Thus, the course provides an understanding of the whole fundraising cycle, from the moment the entrepreneur conceived her idea to the moment investors exit the company and move on. We examine the entrepreneur's signalling to investors of the qualities of the venture, the investors' evaluation of the venture, the various dimensions of contracting (cash flow rights, control rights, compensation, and other clauses), the negotiation of a deal and the provision of corporate governance, the process of staged financing, the financing through debt, and the exit process though liquidity events such as initial public offering, sale or merger. The following topics will be covered with specific case studies: 1. Introduction: Evaluating Venture Opportunities 2. Financial Planning 3. Ownership and Returns 4. Valuation Methods 5. Term Sheets 6. Structuring Deals 7. Corporate Governance 8. Staged Financing 9. Debt Financing 10. Exits 11. Early Stage & Venture Capital Investors 12. Ecosystems
Literature	Da Rin, Marco, and Thomas Hellmann. Fundamentals of Entrepreneurial Finance. Oxford University Press, 2020.

Course L1281: Entrepreneurial Finance: Lecture	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Christoph Ihl
Language	EN
Cycle	WiSe
Content	Entrepreneurial finance is at the center of a clash of two very distant worlds: that of entrepreneurship and that of finance. Finance is disciplined, based on numbers and logical thinking and looking for proven track records. Entrepreneurship is messy, based on intuition and experimentation and treading off the beaten track. Entrepreneurial finance is the provision of funding to young, innovative, growth-oriented companies. Entrepreneurial companies are young, typically less than ten years old, and introduce innovative products or business models. The younger are called “startups,” and are typically less than five years old. There is a variety of investors who can finance entrepreneurial companies: family and friends, business angels, accelerators and incubators, crowdfunding platforms, venture capital firms, corporate investors, etc. The course provides a thorough understanding of what motivates them, of the way they invest, and of what support they can provide to a company at what stage in the fundraising cycle. The course addresses the following key questions: How much money can and should be raised? When should it be raised and from whom? What is a reasonable valuation of the company? How should funding, employment contracts and exit decisions be structured? Thus, the course provides an understanding of the whole fundraising cycle, from the moment the entrepreneur conceived her idea to the moment investors exit the company and move on. We examine the entrepreneur's signalling to investors of the qualities of the venture, the investors' evaluation of the venture, the various dimensions of contracting (cash flow rights, control rights, compensation, and other clauses), the negotiation of a deal and the provision of corporate governance, the process of staged financing, the financing through debt, and the exit process though liquidity events such as initial public offering, sale or merger. The following topics will be covered in lectures: 1. Introduction: Evaluating Venture Opportunities 2. Financial Planning 3. Ownership and Returns 4. Valuation Methods 5. Term Sheets 6. Structuring Deals 7. Corporate Governance 8. Staged Financing 9. Debt Financing 10. Exits 11. Early Stage & Venture Capital Investors 12. Ecosystems
Literature	Da Rin, Marco, and Thomas Hellmann. Fundamentals of Entrepreneurial Finance. Oxford University Press, 2020.

Module M0543: Advanced Topics in Management, Organization, and Human Resource Management

Courses

Title	Typ	Hrs/wk	CP
Advanced Topics in Management, Organization, and Human Resource Management (L0110)	Lecture	2	3
Advanced Topics in Management, Organization, and Human Resource Management (L0111)	Seminar	2	3

Module Responsible	Prof. Christian Ringle
Admission Requirements	None
Recommended Previous Knowledge	Foundations in Organizational Design and Human Resource Management Basic knowledge on academic writing as well as principles and concepts in business administration and foundations in organizational design and human resource management.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students are able to... • Explain the different organizational designs and strategies in an international environment with a focus on selected forms of cooperation (e.g., virtual organizations or strategic alliances) to compete in global business; • Map the need of organizational changes in light of new business lines, strategies, altering employees' attitudes, and international competition; • Explain the models and approaches for appropriately measuring employee relations (e.g., job satisfaction models), incl. the development and estimation of causal models.
Skills	The students are able to... • Work with empirical data, apply business process management and multivariate techniques to the data collected using standard software, and critically evaluate and interpret the results; • Critically rethink theoretical concepts and gain analytical abilities in organization management and human resource management; • Use their practical knowledge of the analytical toolset to successfully tackle the management challenges in organization and human resource management in internationally acting companies; • Present their results in written and oral form.
Personal Competence	
Social Competence	The students are able to... • Respectfully work in teams; • Have fruitful group discussions; • Present their results in written form and oral presentations.
Autonomy	The students are able to... • Acquire further relevant information independently; • Critically reflect and evaluate this information; • Transfer the acquired knowledge to practical applications.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	Compulsory: Yes; Bonus: 20 %; Form: Presentation; Description:
Examination	Subject theoretical and practical work
Examination duration and scale	Thesis with presentation and assignments during the semester
Assignment for the Following Curricula	International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory

Course L0110: Advanced Topics in Management, Organization, and Human Resource Management	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Ringle
Language	EN
Cycle	WiSe
Content	This lecture focuses on multinational firms and advanced issues of management, organizations, and human resource management. This course is structured as a lecture and a seminar. In the lecture, the advanced theoretical concepts are explained and discussed, whereas they are applied in the seminar through the preparation of a seminar thesis. The students learn about the process and structure of a scientific article, and further deepen their knowledge, while working in groups. Example topics: • Management: change management and corporate social responsibility; • Organization: exploration & exploitation, networks, and organizational identity; • Human Resource Management: human resource metrics & analytics and recruitment & selection.
Literature	The students will be provided with selected journal articles. Bernardin, H.J. (2006): Human Resource Management: An Experiential Approach, 4e, New York: McGraw-Hill. Cascio, W. (2015): Managing Human Resources: Productivity, Quality of Work Life, Profits, revised edition, New York: McGraw-Hill. French, W./Bell, C.H./Zawacki, R.A. (2004): Organization Development and Transformation: Managing Effective Change, 6e, Chicago: McGraw-Hill. Hitt, M.A./Ireland, R.D./Hoskisson, R.E. (2014): Strategic Management: Competitiveness and Globalization, 11e, Ohio: Cengage Learning. Lynch, R. (2015): Strategic Management, 7e, Harlow: Prentice Hall.

Course L0111: Advanced Topics in Management, Organization, and Human Resource Management	
Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Ringle
Language	EN
Cycle	WiSe
Content	This course focuses on multinational firms and advanced issues of management, organizations, and human resource management. The students learn about the process and structure of a scientific article and deepen their knowledge while working in groupds. Selected topics focus, for example, on: • Human Resource Management: aging workforce, e-human resource management, generation X, Y, Z, human resource metrics/ analytics, recruitment/ selection/ hiring • Organisation: employee voice, exploration/ exploitation, networks, organisational identity, trust measurement • Management: change management, corporate social responsibility, firm performance measurement, gender, innovation management
Literature	The students will be provided with selected journal articles. Bernardin, H.J. (2006): Human Resource Management: An Experiential Approach, 4e, New York: McGraw-Hill. Cascio, W. (2015): Managing Human Resources: Productivity, Quality of Work Life, Profits, revised edition, New York: McGraw-Hill. French, W./Bell, C.H./Zawacki, R.A. (2004): Organization Development and Transformation: Managing Effective Change, 6e, Chicago: McGraw-Hill. Hitt, M.A./Ireland, R.D./Hoskisson, R.E. (2014): Strategic Management: Competitiveness and Globalization, 11e, Ohio: Cengage Learning. Lynch, R. (2015): Strategic Management, 7e, Harlow: Prentice Hall.

Module M1173: Applied Statistics

Courses

Title	Typ	Hrs/wk	CP
Applied Statistics (L1584)	Lecture	2	3
Applied Statistics (L1586)	Project-/problem-based Learning	2	2
Applied Statistics (L1585)	Recitation Section (small)	1	1

Module Responsible	Prof. Michael Morlock
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of statistical methods
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can explain the statistical methods and the conditions of their use.
Skills	Students are able to use the statistics program to solve statistics problems and to interpret and depict the results
Personal Competence	
Social Competence	Team Work, joined presentation of results
Autonomy	To understand and interpret the question and solve
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 minutes, 28 questions
Assignment for the Following Curricula	Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Biomedical Engineering: Core Qualification: Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

Course L1584: Applied Statistics

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	WiSe
Content	The goal is to introduce students to the basic statistical methods and their application to simple problems. The topics include: • Chi square test • Simple regression and correlation • Multiple regression and correlation • One way analysis of variance • Two way analysis of variance • Discriminant analysis • Analysis of categorial data • Chossing the appropriate statistical method • Determining critical sample sizes
Literature	Applied Regression Analysis and Multivariable Methods, 3rd Edition, David G. Kleinbaum Emory University, Lawrence L. Kupper University of North Carolina at Chapel Hill, Keith E. Muller University of North Carolina at Chapel Hill, Azhar Nizam Emory University, Published by Duxbury Press, CB © 1998, ISBN/ISSN: 0-534-20910-6

Course L1586: Applied Statistics	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	WiSe
Content	The students receive a problem task, which they have to solve in small groups (n=5). They do have to collect their own data and work with them. The results have to be presented in an executive summary at the end of the course.
Literature	Selbst zu finden

Course L1585: Applied Statistics	
Typ	Recitation Section (small)
Hrs/wk	1
CP	1
Workload in Hours	Independent Study Time 16, Study Time in Lecture 14
Lecturer	Prof. Michael Morlock
Language	DE/EN
Cycle	WiSe
Content	The different statistical tests are applied for the solution of realistic problems using actual data sets and the most common used commercial statistical software package (SPSS).
Literature	Student Solutions Manual for Kleinbaum/Kupper/Muller/Nizam's Applied Regression Analysis and Multivariable Methods, 3rd Edition, David G. Kleinbaum Emory University Lawrence L. Kupper University of North Carolina at Chapel Hill, Keith E. Muller University of North Carolina at Chapel Hill, Azhar Nizam Emory University, Published by Duxbury Press, Paperbound © 1998, ISBN/ISSN: 0-534-20913-0

Module M0815: Product Planning

Courses

Title	Typ	Hrs/wk	CP
Product Planning (L0851)	Lecture	3	3
Product Planning Seminar (L0853)	Project-/problem-based Learning	2	3

Module Responsible	Prof. Cornelius Herstatt
Admission Requirements	None
Recommended Previous Knowledge	Good basic-knowledge of Business Administration
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	

Knowledge	Students will gain insights into:
	• Product Planning
	  ◦ Process
	  ◦ Methods
	• Design thinking
	  ◦ Process
	  ◦ Methods
	  ◦ User integration

Skills	Students will gain deep insights into:
	• Product Planning
	  ◦ Process-related aspects
	  ◦ Organisational-related aspects
	  ◦ Human-Ressource related aspects
	  ◦ Working-tools, methods and instruments
	  ◦

Personal Competence	
Social Competence	• Interact within a team • Raise awareness for globabl issues
Autonomy	• Gain access to knowledge sources • Interpret complex cases • Develop presentation skills
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	Compulsory: Yes; Bonus: 20 %; Form: Subject theoretical and practical work; Description:
Examination	Thesis
Examination duration and scale	90 minutes
Assignment for the Following Curricula	Global Innovation Management: Core Qualification: Compulsory International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory Mechanical Engineering and Management: Specialisation Management: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory

Course L0851: Product Planning	
Typ	Lecture
Hrs/wk	3
CP	3
Workload in Hours	Independent Study Time 48, Study Time in Lecture 42
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	Product Planning Process This integrated lecture is designed to understand major issues, activities and tools in the context of systematic product planning, a key activity for managing the front-end of innovation, i.e.: • Systematic scanning of markets for innovation opportunities • Understanding strengths/weakness and specific core competences of a firm as platforms for innovation • Exploring relevant sources for innovation (customers, suppliers, Lead Users, etc.) • Developing ideas for radical innovation, relying on the creativeness of employees, using techniques to stimulate creativity and creating a stimulating environment • Transferring ideas for innovation into feasible concepts which have a high market attractively Voluntary presentations in the third hour (articles / case studies) - Guest lectures by researchers - Lecture on Sustainability with frequent reference to current research - Permanent reference to current research Examination: In addition to the written exam at the end of the module, students have to attend the PBL-exercises and prepare presentations in groups in order to pass the module. Additionally, students have the opportunity to present research papers on a voluntary base. With these presentations it is possible to gain a bonus of max. 20% for the exam. However, the bonus is only valid if the exam is passed without the bonus.
Literature	Ulrich, K./Eppinger, S.: Product Design and Development, 2nd. Edition, McGraw-Hill 2010

Course L0853: Product Planning Seminar	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Cornelius Herstatt
Language	EN
Cycle	WiSe
Content	Seminar is integrative part of the Module Product Planning (for content see lecture) and can not be choosen independantly.
Literature	See lecture information "Product Planning".

Specialization Mechatronics

Graduates of the Mechatronics specialization are able to solve mechatronic tasks as well as design tasks systematically and methodically. They have knowledge about current methods, automation and simulation, are able to choose between different strategies and to use them independently for the development of new systems.

The Mechatronics specialization is recommended to students who already bring along basic knowledge in measurement technology, control engineering and computer science.

Module M0751: Vibration Theory

Courses

Title	Typ	Hrs/wk	CP
Vibration Theory (L0701)	Integrated Lecture	4	6

Module Responsible	Prof. Norbert Hoffmann
Admission Requirements	None
Recommended Previous Knowledge	• Calculus • Linear Algebra • Engineering Mechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to denote terms and concepts of Vibration Theory and develop them further. • Students know methods of modeling and simulation for free, driven, self-excited and parameter driven vibrations. • Students know about concepts of linear and nonlinear vibration problems. • Students know basic tasks of vibration problems of discrete and continuous systems.
Skills	• Students are able to denote methods of Vibration Theory and develop them further. • Students are able to apply and expand methods of modeling and simulation for free, forced, self-excited and parameter driven vibrations. • Students are able to solve linear and nonlinear vibration problems.
Personal Competence	
Social Competence	• Students can analyze vibration problems, work on them, and reach working results also in teams or groups. • Students are able to document the results of vibration studies also in groups.
Autonomy	• Students are able to individually analyze and solve vibration problems. • Students are able to approach individually research tasks in Vibration Theory.
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	2 Hours
Assignment for the Following Curricula	Energy Systems: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: 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 Product Development, Materials and Production: Core Qualification: Compulsory Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory

Course L0701: Vibration Theory	
Typ	Integrated Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Norbert Hoffmann
Language	DE/EN
Cycle	WiSe
Content	Linear and Nonlinear Single and Multiple Degree of Freedom Vibrations • Free vibration • Self-excited vibration • Parameter driven vibration • Forced vibration • Multi degree of freedom vibration • Continuum vibration • Irregular vibration
Literature	German - K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen. English - K. Magnus: Vibrations.

Module M0752: Nonlinear Dynamics

Courses

Title	Typ	Hrs/wk	CP
Nonlinear Dynamics (L0702)	Integrated Lecture	4	6

Module Responsible	Prof. Norbert Hoffmann
Admission Requirements	None
Recommended Previous Knowledge	• Calculus • Linear Algebra • Engineering Mechanics
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students are able to reflect existing terms and concepts in Nonlinear Dynamics and to develop and research new terms and concepts. • Students are able to denote and expand methods of modeling and analysis for nonlinear dynamical systems.
Skills	• Students are able to apply existing methods and procesures of Nonlinear Dynamics. • Students are able to develop novel methods and procedures for nonlinear dynamical systems.
Personal Competence	
Social Competence	• Students can analyze problems of nonlinear dynamics also in groups. • Students can achieve solution procedures for problems of nonlinear dynamical systems also in groups.
Autonomy	• Students are able to approach given research tasks on the basis of given methods individually. • Students are able to identify and follow up novel research tasks by themselves.
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	2 Hours
Assignment for the Following Curricula	Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Aeronautics: Core Qualification: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: 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 Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory

Course L0702: Nonlinear Dynamics	
Typ	Integrated Lecture
Hrs/wk	4
CP	6
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Lecturer	Prof. Norbert Hoffmann
Language	DE/EN
Cycle	SoSe

Content	Fundamentals of Nonlinear Dynamics
	• One dimensional problems
	  ◦ Linear Stability
	  ◦ Local Bifurcations
	  ◦ Synchronisation
	• Two dimensional problems
	  ◦ Limit Cycles
	  ◦ Global Bifurcations
	• Chaos
	  ◦ Lorenz Equations
	  ◦ Fractals and Strange Attractors
	  ◦ Predictability and Horizons

Literature	Steven Strogatz: Nonlinear Dynamics and Chaos.

Module M0846: Control Systems Theory and Design

Courses

Title	Typ	Hrs/wk	CP
Control Systems Theory and Design (L0656)	Lecture	2	4
Control Systems Theory and Design (L0657)	Recitation Section (small)	2	2

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	Introduction to Control Systems
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can explain how linear dynamic systems are represented as state space models; they can interpret the system response to initial states or external excitation as trajectories in state space • They can explain the system properties controllability and observability, and their relationship to state feedback and state estimation, respectively • They can explain the significance of a minimal realisation • They can explain observer-based state feedback and how it can be used to achieve tracking and disturbance rejection • They can extend all of the above to multi-input multi-output systems • They can explain the z-transform and its relationship with the Laplace Transform • They can explain state space models and transfer function models of discrete-time systems • They can explain the experimental identification of ARX models of dynamic systems, and how the identification problem can be solved by solving a normal equation • They can explain how a state space model can be constructed from a discrete-time impulse response
Skills	• Students can transform transfer function models into state space models and vice versa • They can assess controllability and observability and construct minimal realisations • They can design LQG controllers for multivariable plants • They can carry out a controller design both in continuous-time and discrete-time domain, and decide which is appropriate for a given sampling rate • They can identify transfer function models and state space models of dynamic systems from experimental data • They can carry out all these tasks using standard software tools (Matlab Control Toolbox, System Identification Toolbox, Simulink)
Personal Competence	
Social Competence	Students can work in small groups on specific problems to arrive at joint solutions.
Autonomy	Students can obtain information from provided sources (lecture notes, software documentation, experiment guides) and use it when solving given problems. They can assess their knowledge in weekly on-line tests and thereby control their learning progress.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	120 min
Assignment for the Following Curricula	Electrical Engineering: Core Qualification: Compulsory Energy Systems: Core Qualification: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory Aeronautics: Core Qualification: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Core Qualification: 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: Compulsory Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Compulsory

Course L0656: Control Systems Theory and Design	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	NN
Language	EN
Cycle	WiSe
Content	State space methods (single-input single-output) • State space models and transfer functions, state feedback • Coordinate basis, similarity transformations • Solutions of state equations, matrix exponentials, Caley-Hamilton Theorem • Controllability and pole placement • State estimation, observability, Kalman decomposition • Observer-based state feedback control, reference tracking • Transmission zeros • Optimal pole placement, symmetric root locus Multi-input multi-output systems • Transfer function matrices, state space models of multivariable systems, Gilbert realization • Poles and zeros of multivariable systems, minimal realization • Closed-loop stability • Pole placement for multivariable systems, LQR design, Kalman filter Digital Control • Discrete-time systems: difference equations and z-transform • Discrete-time state space models, sampled data systems, poles and zeros • Frequency response of sampled data systems, choice of sampling rate System identification and model order reduction • Least squares estimation, ARX models, persistent excitation • Identification of state space models, subspace identification • Balanced realization and model order reduction Case study • Modelling and multivariable control of a process evaporator using Matlab and Simulink Software tools • Matlab/Simulink
Literature	• Werner, H., Lecture Notes „Control Systems Theory and Design“ • T. Kailath "Linear Systems", Prentice Hall, 1980 • K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997 • L. Ljung "System Identification - Theory for the User", Prentice Hall, 1999

Course L0657: Control Systems Theory and Design	
Typ	Recitation Section (small)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	NN
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0746: Microsystem Engineering

Courses

Title	Typ	Hrs/wk	CP
Microsystem Engineering (L0680)	Lecture	2	4
Microsystem Engineering (L0682)	Project-/problem-based Learning	2	2

Module Responsible	Dr. Timo Lipka
Admission Requirements	None
Recommended Previous Knowledge	Basic courses in physics, mathematics and electric engineering
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students know about the most important technologies and materials of MEMS as well as their applications in sensors and actuators.
Skills	Students are able to analyze and describe the functional behaviour of MEMS components and to evaluate the potential of microsystems.
Personal Competence	
Social Competence	Students are able to solve specific problems alone or in a group and to present the results accordingly.
Autonomy	Students are able to acquire particular knowledge using specialized literature and to integrate and associate this knowledge with other fields.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description**: No / 10 % / Presentation
Examination	Written exam
Examination duration and scale	2h
Assignment for the Following Curricula	Electrical Engineering: Core Qualification: Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Microelectronics and Microsystems: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

Course L0680: Microsystem Engineering	
Typ	Lecture
Hrs/wk	2
CP	4
Workload in Hours	Independent Study Time 92, Study Time in Lecture 28
Lecturer	Dr. Timo Lipka
Language	EN
Cycle	WiSe
Content	Object and goal of MEMS Scaling Rules Lithography Film deposition Structuring and etching Energy conversion and force generation Electromagnetic Actuators Reluctance motors Piezoelectric actuators, bi-metal-actuator Transducer principles Signal detection and signal processing Mechanical and physical sensors Acceleration sensor, pressure sensor Sensor arrays System integration Yield, test and reliability
Literature	M. Kasper: Mikrosystementwurf, Springer (2000) M. Madou: Fundamentals of Microfabrication, CRC Press (1997)

Course L0682: Microsystem Engineering	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Dr. Timo Lipka
Language	EN
Cycle	WiSe
Content	Examples of MEMS components Layout consideration Electric, thermal and mechanical behaviour Design aspects
Literature	Wird in der Veranstaltung bekannt gegeben

Module M0925: Digital Circuit Design

Courses

Title	Typ	Hrs/wk	CP
Digital Circuit Design (L0698)	Lecture	2	3
Advanced Digital Circuit Design (L0699)	Lecture	2	3

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence *Knowledge* *Skills* **Personal Competence** *Social Competence* *Autonomy*	
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Oral exam
Examination duration and scale	40 min
Assignment for the Following Curricula	Electrical Engineering: Specialisation Nanoelectronics and Microsystems Technology: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory Microelectronics and Microsystems: Specialisation Embedded Systems: Elective Compulsory

Course L0698: Digital Circuit Design

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Volkhard Klinger
Language	EN
Cycle	WiSe
Content	
Literature	

Course L0699: Advanced Digital Circuit Design

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

Module M0677: Digital Signal Processing and Digital Filters

Courses

Title	Typ	Hrs/wk	CP
Digital Signal Processing and Digital Filters (L0446)	Lecture	3	4
Digital Signal Processing and Digital Filters (L0447)	Recitation Section (large)	2	2

Module Responsible	Prof. Gerhard Bauch
Admission Requirements	None
Recommended Previous Knowledge	• Mathematics 1-3 • Signals and Systems • Fundamentals of signal and system theory as well as random processes. • Fundamentals of spectral transforms (Fourier series, Fourier transform, Laplace transform)
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students know and understand basic algorithms of digital signal processing. They are familiar with the spectral transforms of discrete-time signals and are able to describe and analyse signals and systems in time and image domain. They know basic structures of digital filters and can identify and assess important properties including stability. They are aware of the effects caused by quantization of filter coefficients and signals. They are familiar with the basics of adaptive filters. They can perform traditional and parametric methods of spectrum estimation, also taking a limited observation window into account. The students are familiar with the contents of lecture and tutorials. They can explain and apply them to new problems.
Skills	The students are able to apply methods of digital signal processing to new problems. They can choose and parameterize suitable filter striuctures. In particular, the can design adaptive filters according to the minimum mean squared error (MMSE) criterion and develop an efficient implementation, e.g. based on the LMS or RLS algorithm. Furthermore, the students are able to apply methods of spectrum estimation and to take the effects of a limited observation window into account.
Personal Competence	
Social Competence	The students can jointly solve specific problems.
Autonomy	The students are able to acquire relevant information from appropriate literature sources. They can control their level of knowledge during the lecture period by solving tutorial problems, software tools, clicker system.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Computer Science in Engineering: Specialisation II. Engineering Science: Elective Compulsory Information and Communication Systems: Specialisation Communication Systems, Focus Signal Processing: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Microelectronics and Microsystems: Specialisation Communication and Signal Processing: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory

Course L0446: Digital Signal Processing and Digital Filters	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Gerhard Bauch
Language	EN
Cycle	WiSe

Content	• Transforms of discrete-time signals:
	  ◦ Discrete-time Fourier Transform (DTFT)
	  ◦ Discrete Fourier-Transform (DFT), Fast Fourier Transform (FFT)
	  ◦ Z-Transform
	• Correspondence of continuous-time and discrete-time signals, sampling, sampling theorem
	• Fast convolution, Overlap-Add-Method, Overlap-Save-Method
	• Fundamental structures and basic types of digital filters
	• Characterization of digital filters using pole-zero plots, important properties of digital filters
	• Quantization effects
	• Design of linear-phase filters
	• Fundamentals of stochastic signal processing and adaptive filters
	  ◦ MMSE criterion
	  ◦ Wiener Filter
	  ◦ LMS- and RLS-algorithm
	• Traditional and parametric methods of spectrum estimation

Literature	K.-D. Kammeyer, K. Kroschel: Digitale Signalverarbeitung. Vieweg Teubner. V. Oppenheim, R. W. Schafer, J. R. Buck: Zeitdiskrete Signalverarbeitung. Pearson StudiumA. V. W. Hess: Digitale Filter. Teubner. Oppenheim, R. W. Schafer: Digital signal processing. Prentice Hall. S. Haykin: Adaptive flter theory. L. B. Jackson: Digital filters and signal processing. Kluwer. T.W. Parks, C.S. Burrus: Digital filter design. Wiley.

Course L0447: Digital Signal Processing and Digital Filters	
Typ	Recitation Section (large)
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Gerhard Bauch
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M0633: Industrial Process Automation

Courses

Title	Typ	Hrs/wk	CP
Industrial Process Automation (L0344)	Lecture	2	3
Industrial Process Automation (L0345)	Recitation Section (small)	2	3

Module Responsible	Prof. Alexander Schlaefer
Admission Requirements	None
Recommended Previous Knowledge	mathematics and optimization methods principles of automata principles of algorithms and data structures programming skills
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students can evaluate and assess discrete event systems. They can evaluate properties of processes and explain methods for process analysis. The students can compare methods for process modelling and select an appropriate method for actual problems. They can discuss scheduling methods in the context of actual problems and give a detailed explanation of advantages and disadvantages of different programming methods. The students can relate process automation to methods from robotics and sensor systems as well as to recent topics like 'cyberphysical systems' and 'industry 4.0'.
Skills	The students are able to develop and model processes and evaluate them accordingly. This involves taking into account optimal scheduling, understanding algorithmic complexity, and implementation using PLCs.
Personal Competence	
Social Competence	The students can independently define work processes within their groups, distribute tasks within the group and develop solutions collaboratively.
Autonomy	The students are able to assess their level of knowledge and to document their work results adequately.
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	**Compulsory** / **Bonus** / **Form** / **Description** No / 10 % / Excercises
Examination	Written exam
Examination duration and scale	90 minutes
Assignment for the Following Curricula	Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory Aircraft Systems Engineering: Core Qualification: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory Aeronautics: Core Qualification: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory Process Engineering: Specialisation Process Engineering: Elective Compulsory

Course L0344: Industrial Process Automation	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	- foundations of problem solving and system modeling, discrete event systems - properties of processes, modeling using automata and Petri-nets - design considerations for processes (mutex, deadlock avoidance, liveness) - optimal scheduling for processes - optimal decisions when planning manufacturing systems, decisions under uncertainty - software design and software architectures for automation, PLCs
Literature	J. Lunze: „Automatisierungstechnik“, Oldenbourg Verlag, 2012 Reisig: Petrinetze: Modellierungstechnik, Analysemethoden, Fallstudien; Vieweg+Teubner 2010 Hrúz, Zhou: Modeling and Control of Discrete-event Dynamic Systems; Springer 2007 Li, Zhou: Deadlock Resolution in Automated Manufacturing Systems, Springer 2009 Pinedo: Planning and Scheduling in Manufacturing and Services, Springer 2009

Course L0345: Industrial Process Automation	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Alexander Schlaefer
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Module M1048: Integrated Circuit Design

Courses

Title	Typ	Hrs/wk	CP
Integrated Circuit Design (L0691)	Lecture	3	4
Integrated Circuit Design (L0998)	Recitation Section (small)	1	2

Module Responsible	NN
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge of (solid-state) physics and mathematics. Knowledge in fundamentals of electrical engineering and electrical networks.
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• Students can explain basic concepts of electron transport in semiconductor devices (energy bands, generation/recombination, carrier concentrations, drift and diffusion current densities, semiconductor device equations). • Students are able to explain functional principles of pn-diodes, MOS capacitors, and MOSFETs using energy band diagrams. • Students can present and discuss current-voltage relationships and small-signal equivalent circuits of these devices. • Students can explain the physics and current-voltage behavior transistors based on charged carrier flow. • Students are able to explain the basic concepts for static and dynamic logic gates for integrated circuits • Students can exemplify approaches for low power consumption on the device and circuit level • Students can describe the potential and limitations of analytical expression for device and circuit analysis. • Students can explain characterization techniques for MOS devices.
Skills	• Students can qualitatively construct energy band diagrams of the devices for varying applied voltages. • Students are able to qualitatively determine electric field, carrier concentrations, and charge flow from energy band diagrams. • Students can understand scientific publications from the field of semiconductor devices. • Students can calculate the dimensions of MOS devices in dependence of the circuits properties • Students can design complex electronic circuits and anticipate possible problems. • Students know procedure for optimization regarding high performance and low power consumption
Personal Competence	
Social Competence	• Students can team up with other experts in the field to work out innovative solutions. • Students are able to work by their own or in small groups for solving problems and answer scientific questions. • Students have the ability to critically question the value of their contributions to working groups.
Autonomy	• Students are able to assess their knowledge in a realistic manner. • Students are able to define their personal approaches to solve challenging problems
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	90 min
Assignment for the Following Curricula	Electrical Engineering: Specialisation Nanoelectronics and Microsystems Technology: Elective Compulsory International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory Mechatronics: Specialisation System Design: Elective Compulsory Mechatronics: Core Qualification: Elective Compulsory Microelectronics and Microsystems: Core Qualification: Elective Compulsory

Course L0691: Integrated Circuit Design	
Typ	Lecture
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	• Electron transport in semiconductors • Electronic operating principles of diodes, MOS capacitors, and MOS field-effect transistors • MOS transistor as four terminal device • Performace degradation due to short channel effects • Scaling-down of MOS technology • Digital logic circuits • Basic analog circuits • Operational amplifiers • Bipolar and BiCMOS circuits
Literature	• Yuan Taur, Tak H. Ning: Fundamentals of Modern VLSI Devices, Cambridge University Press 1998 • R. Jacob Baker: CMOS, Circuit Design, Layout and Simulation, IEEE Press, Wiley Interscience, 3rd Edition, 2010 • Neil H.E. Weste and David Money Harris, Integrated Circuit Design, Pearson, 4th International Edition, 2013 • John E. Ayers, Digital Integrated Circuits: Analysis and Design, CRC Press, 2009 • Richard C. Jaeger and Travis N. Blalock: Microelectronic Circuit Design, Mc Graw-Hill, 4rd. Edition, 2010

Course L0998: Integrated Circuit Design	
Typ	Recitation Section (small)
Hrs/wk	1
CP	2
Workload in Hours	Independent Study Time 46, Study Time in Lecture 14
Lecturer	Prof. Matthias Kuhl
Language	EN
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Specialization Product Development and Production

Graduates of the Product Development and Production specialization have profound knowledge of different manufacturing and production processes and can choose between them in consideration of geometry, failure control and cost. They are able to design, calculate and simulate according to the current state of the art.

The Product Development and Production specialization is recommended to students who already have basic knowledge in design methods, calculation of components and different manufacturing processes.

Module M0604: High-Order FEM

Courses

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

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

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

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

Module M1256: AdditiveProduction

Courses

Title	Typ	Hrs/wk	CP
Additive Production (L1128)	Lecture	2	3
Additive Production (L1129)	Seminar	2	3

Module Responsible	Prof. Claus Emmelmann
Admission Requirements	None
Recommended Previous Knowledge	• Production Engineering • Fundamental of Material Science • Fundamentals of Mechanical Engineering Design
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to: • give an overview of Additive Manufacturing Technologies, namely • describe basics of Laser Technologies • discuss laser Additive Manufacturing, specifically • design Guidelines for Additive Manufacturing • describe the Digital Process Chain for Additive Manufacturing • discuss Quality Assurance for Additive Manufacturing • describe Product Development for Additive Manufacturing
Skills	The students will be able to: • give an overview of Potential and Challenges of Additive Manufacturing Technologies • show that Additive Manufacturing offers new possibilities for product development • show major differences between Additive Manufacturing and conventional manufacturing technologies • apply basic skills to develop and design Additive Manufacturing parts • design and build own Additive Manufacturing parts
Personal Competence	
Social Competence	Students are able to • interact within a team • organize workload in a team
Autonomy	Students are able to • develop and optimize a product with limited resources, based on defined requirements • present results skillfully
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	75 min
Assignment for the Following Curricula	Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory

Course L1128: Additive Production

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Claus Emmelmann
Language	EN
Cycle	SoSe
Content	Learn the Basics of Additive Manufacturing, with focus on the Selective Laser Melting and Selective Laser Sintering. Understand the advantages the technologies offer for product development and what current challenges Additive Manufacturing faces. Get to know the design restrictions as well as basic knowledge about material characteristics, post processing and quality assurance. **This lecture is part of the Module Rapid Production and cannot be chosen separately**
Literature	Will be announced during the course

Course L1129: Additive Production	
Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Claus Emmelmann
Language	EN
Cycle	SoSe
Content	Intensify learning from the lecture, especially regarding design principles and product development by design of own Selective Laser Sintering parts. **This seminar is part of the Module Rapid Production and cannot be chosen separately.**
Literature	Will be announced during the course

Module M1143: Applied Design Methodology in Mechatronics

Courses

Title	Typ	Hrs/wk	CP
Applied Design Methodology in Mechatronics (L1523)	Lecture	2	2
Applied Design Methodology in Mechatronics (L1524)	Project-/problem-based Learning	3	4

Module Responsible	Prof. Thorsten Kern
Admission Requirements	None
Recommended Previous Knowledge	Basics of mechanical design, electrical design or computer-sciences
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Science-based working on interdisciplinary product design considering targeted application of specific product design techniques
Skills	Creative handling of processes used for scientific preparation and formulation of complex product design problems / Application of various product design techniques following theoretical aspects.
Personal Competence	
Social Competence	Students will solve and execute technical-scientific tasks from an industrial context in small design-teams with application of common, creative methodologies.
Autonomy	Students are enabled to optimize the design and development process according to the target and topic of the design Students are educated to operate in a development team Students learn about the right application of creative methods in engineering.
Workload in Hours	Independent Study Time 110, Study Time in Lecture 70
Credit points	6
Course achievement	None
Examination	Subject theoretical and practical work
Examination duration and scale	30 min Presentation for a group design-work
Assignment for the Following Curricula	International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory Mechatronics: Core Qualification: 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 Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory

Course L1523: Applied Design Methodology in Mechatronics	
Typ	Lecture
Hrs/wk	2
CP	2
Workload in Hours	Independent Study Time 32, Study Time in Lecture 28
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	SoSe
Content	• Systematic analysis and planning of the design process for products combining a multitude of disciplines • Structure of the engineering process with focus on engineering steps (task-definition, functional decomposition, physical principles, elements for solution, combination to systems and products, execution of design, component-tests, system-tests, product-testing and qualification/validation) • Creative methods (Basics, methods like lead-user-method, 6-3-5, BrainStorming, Intergalactic Thinking, ... - Applications in examples all around mechatronics topics) • Several design-supporting methods and tools (functional strcutures, GALFMOS, AEIOU-method, GAMPFT, simulation and its application, TRIZ, design for SixSigma, continous integration and testing, ...) • Evaluation and final selection of solution (technical and business-considerations, preference-matrix, pair-comparision), dealing with uncertainties, decision-making • Value-analysis • Derivation of architectures and architectural management • Project-tracking and -guidance (project-lead, guiding of employees, organization of multidisciplinary R&D departments, idea-identification, responsibilities and communication) • Project-execution methods (Scrum, Kanbaan, ...) • Presentation-skills • Questions of aesthetic product design and design for subjective requirements (industrial design, color, haptic/optic/acoustic interfaces) • Evaluation of selected methods at practical examples in small teams
Literature	• Definition folgt... • Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, K.-H.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoden und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007 • VDI-Richtlinien: 2206; 2221ff

Course L1524: Applied Design Methodology in Mechatronics	
Typ	Project-/problem-based Learning
Hrs/wk	3
CP	4
Workload in Hours	Independent Study Time 78, Study Time in Lecture 42
Lecturer	Prof. Thorsten Kern
Language	EN
Cycle	SoSe
Content	See interlocking course
Literature	See interlocking course

Module M1257: 3D Printing Laboratory

Courses

Title	Typ	Hrs/wk	CP
3D Printing Laboratory (L1701)	Practical Course	3	6

Module Responsible	Prof. Claus Emmelmann
Admission Requirements	None
Recommended Previous Knowledge	Rapid Production Computer Aided Design and Computation
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students will be able to give an overview over • 3D printing based on fused deposition modeling, • printer setup and hardware components, • software and CAD data preparation, • and process parameters and quality aspects.
Skills	The students will be able to • prepare CAD models for 3D printing, • calibrate and operate a 3D printer, • conduct designed experiments, • and find optimal printing parameters.
Personal Competence	
Social Competence	The students will be able to • coordinate work in a team, • set up, monitor and adapt a project plan, • share information with team members, • deal with different personal knowledge backgrounds, • and handle team conflicts.
Autonomy	Without external support the students will be able to • do literature research, • organize work according to a schedule, • conduct experiments, • and operate and troubleshoot a production machine.
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42
Credit points	6
Course achievement	None
Examination	Written elaboration
Examination duration and scale	ca. 30 pages, approximately eight hours of preparation
Assignment for the Following Curricula	Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory

Course L1701: 3D Printing Laboratory

Typ	Practical Course
Hrs/wk	3
CP	6
Workload in Hours	Independent Study Time 138, Study Time in Lecture 42
Lecturer	Prof. Claus Emmelmann
Language	EN
Cycle	WiSe
Content	The 3D Printing lab consists of: · Preparation of CAD models for 3D printing, · Design of Experiments for 3D-printing · Hands-on operation of 3D printer · Printing parameter variation and detection of influences on the process
Literature	wird in der Veranstaltung bekannt gegeben

Module M1258: Laser Systems and Metallic Materials

Courses

Title	Typ	Hrs/wk	CP
Laser Systems and Process Technologies (L1612)	Lecture	2	3
Structural Metallic Materials (L1702)	Lecture	2	3

Module Responsible	Prof. Claus Emmelmann
Admission Requirements	None
Recommended Previous Knowledge	Fundamentals of Materials Science I
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can give an overview over laser systems for material processing, specifically: • beam sources, • transport and manipulation of Laser beams, • and laser Safety. They can also describe applications of laser systems in material processing, namely: • primary forming, • marking, • cutting, • joining, • and surface treatment. They can also explain the material science of technically relevant metals as for example • carbon steels, • micro alloyed steels • low- and high-alloyed steels, • stainless steels, • aluminium alloys, • and magnesium alloys.
Skills	After successful completion of this course, students should be able to • give an overview on current laser technology, • classify its applications in today's manufacturing processes, • evaluate economical and quality aspects, • find suitable laser systems for given tasks.
Personal Competence	
Social Competence	• Students are able to discuss their solutions to problems with others. They communicate in English.
Autonomy	• Students are able of checking their understanding of complex concepts by solving variants of concrete problems
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	approx. 20 pages
Assignment for the Following Curricula	Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory

Course L1612: Laser Systems and Process Technologies	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Claus Emmelmann
Language	EN
Cycle	WiSe
Content	• Fundamentals of laser technology • Laser beam sources: CO2-, Nd:YAG-, Fiber- and Diodelasers • Laser system technology: beam forming, beam guidance systems, beam motion and beam control • Laser-based manufacturing technologies: generation, marking, cutting, joining, surface treatment • Quality assurance and economical aspects of laser material processing • Markets and Applications of laser technology • Student group exercises
Literature	• Hügel, H. , T. Graf: Laser in der Fertigung : Strahlquellen, Systeme, Fertigungsverfahren, 3. Aufl., Vieweg + Teubner Wiesbaden 2014. • Eichler, J., Eichler. H. J.: Laser: Bauformen, Strahlführung, Anwendungen, 7. Aufl., Springer-Verlag Berlin Heidelberg 2010. • Steen W. M.; Mazumder J.: Laser material processing, 4th Edition, Springer-Verlag London 2010. • J.C. Ion: Laser processing of engineering materials: principles, procedure and industrial applications, Elsevier Butterworth-Heinemann 2005. • Gebhardt, A.: Understanding additive manufacturing, München [u.a.] Hanser 2011

Course L1702: Structural Metallic Materials	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	PD Dr. Nikolai Kashaev
Language	EN
Cycle	WiSe
Content	The course enfolds the relationships between metallic materials, their properties, processing technologies as well as fields of application. Because of the ever-increasing loads and demands for resource efficiency, the optimization of material properties through the tailored processing as well as the targeted sequence of processing steps for the manufacturing of the final part are becoming more important than ever. In terms of selecting of an appropriate material for a targeted application, the necessary and appropriate manufacturing technologies have to be taking into consideration. In order to reflect the effects of manufacturing methods, students are imparted knowledge about metallic materials combined with processing technologies. Particular attention is also paid to loading cases as well as damage mechanisms of the materials used in industrial applications. Furthermore, the possible methods for life extension are analysed and discussed. The aim of the course is to make students aware to perform a correct selection of appropriate materials with technological processes for potential applications taking into consideration the different kinds of stress (fatigue, creep, corrosion etc.). Lecture 1: Introduction. Requirements to structural metallic materials depending on their application. Typical examples for material usage in automotive, airplane and wind energy structures, power plants structures as well as in automotive components including transmissions, bearings, engines etc. Classification of the used materials into groups depending on their application requirements. Lecture 2: Fundamental aspects of Fe-C-alloys. Mechanical properties, material classes (austenitic and ferritic steels, cast iron etc.), Fe-C phase diagram. Fundamental aspects of heat treatment for Fe-base materials. Discussion of specific alloys and their typical applications. Lecture 3: Fundamentals of Fe-base materials processing for fabrication of components. From raw material to the component. Typical fabrication routes: casting, forging, machining. Fundamentals of common manufacturing technologies. Cold forming and forging of steels. Fundamentals of formability and materials strengthening mechanisms, typical alloys and applications (e.g. TRIP steels). Lecture 4: Fundamental aspects of Al-alloys and their base processing technologies for fabrication of components. Fundamental aspects of Mg-alloys and their base processing technologies for fabrication of components. Lecture 5: Fundamental aspects of Ti-alloys and their base processing technologies for fabrication of components. Intermetallic alloys and metallic glasses: properties, applications and fundamental aspects of production and processing. Lecture 6: Cu-base alloys: classes of alloys, their typical applications and fundamental aspects of processing; examples for components. Ni- und Co-base alloys: classes of alloys, their properties and typical applications. Fundamental aspects of processing and manufacturing of components. Lecture 7: Fatigue and fracture of metallic materials. Fundamental aspects of fatigue loading (stress amplitudes, mean stress, high- and low cycle fatigue). Notch effects, crack initiation and propagation. Damage tolerance assessment. Lecture 8: Degradation and failure of materials and components in service. Stress corrosion cracking and corrosion fatigue of metallic materials. Lecture 9: Surface engineering: coatings. Functional coatings for wear and corrosion protection, as well as decorative purposes. Electrochemical and physical coating deposition, deposit welding and thermal spraying. Lecture 10: Surface engineering: modifications. Metallurgical surface modifications (nitriding, surface hardening ect.) and (thermo-)mechanical methods (shot peening, laser shock peening, rolling, friction stir processing ect.).
Literature	1. George Krauss, Steels: Processing, Structure, and Performance, 978-0-87170-817-5, 2006. 2. Hans Berns, Werner Theisen, Ferrous Materials: Steel and Cast Iron, 2008. http://dx.doi.org/10.1007/978-3-540-71848-2 3. Bruno C., De Cooman / John G. Speer: Fundamentals of Steel Product Physical Metallurgy, 2011, 642 S. 4. Harry Chandler, Steel Metallurgy for the Non-Metallurgist 0-87170-652-0, 2006, 84 S. 5. Catrin Kammer, Aluminium Taschenbuch 1, Grundlagen und Werkstoffe, Beuth,16. Auflage 2009. 784 S., ISBN 978-3-410-22028-2 6. Günter Drossel, Susanne Friedrich, Catrin Kammer und Wolfgang Lehnert, Aluminium Taschenbuch 2, Umformung von Aluminium-Werkstoffen, Gießen von Aluminiumteilen, Oberflächenbehandlung von Aluminium, Recycling und Ökologie, Beuth, 16. Auflage 2009. 768 S., ISBN 978-3-410-22029-9 7. Catrin Kammer, Aluminium Taschenbuch 3, Weiterverarbeitung und Anwendung, Beuith,17. Auflage 2014. 892 S., ISBN 978-3-410-22311-5 8. Lütjering, J.C. Williams: Titanium, 2nd ed., Springer, Berlin, Heidelberg, 2007, ISBN 978-3-540-71397 9. Magnesium - Alloys and Technologies, K. U. Kainer (Hrsg.), Wiley-VCH, Weinheim 2003, ISBN 3-527-30570-x 10. Mihriban O. Pekguleryuz, Karl U. Kainer and Ali Kaya “Fundamentals of Magnesium Alloy Metallurgy”, Woodhead Publishing Ltd, 2013,ISBN 10: 0857090887

Specialization Materials

Graduates of the Materials specialization are able to work in development, manufacturing and application of materials. They can identify new application fields of materials and make choices between different materials in consideration of functions, cost and quality.

The Materials specialization is recommended to students who already have basic knowledge about different materials and know how to calculate with material properties.

Module M1150: Continuum Mechanics

Courses

Title	Typ	Hrs/wk	CP
Continuum Mechanics (L1533)	Lecture	2	3
Continuum Mechanics Exercise (L1534)	Recitation Section (small)	2	3

Module Responsible	Prof. Christian Cyron
Admission Requirements	None
Recommended Previous Knowledge	Basics of mechanics as taught, e.g., in the modules Engineering Mechanics I and Engineering Mechanics II at TUHH (forces and moments, stress, linear strain, free-body principle, linear-elastic constitutive laws, strain energy); basics of mathematics as taught, e.g., in the modules Mathematics I and Mathematics II at TUHH
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	In this module, students learn the fundamental concepts of nonlinear continuum mechanics. This theory enables students to describe arbitrary deformations of continuous bodies (solid, liquid or gaseous) under arbitrary loads. The module is a continuation of the basic module Engineering Mechanics II (elastostatics), the limiting assumptions (isotropic, linear-elastic material behavior, small deformations, simple geometries) of which are successively eliminated. First, the students learn the necessary fundamentals of tensor calculus. Based on this, the description of the deformations / strains of arbitrarily deformable bodies is dealt with. The students learn the mathematical formalism for characterizing the stress state of a body and for formulating the balance equations for mass, momentum, energy and entropy in various forms. Furthermore, the students know which constitutive assumptions have to be made for modeling the material behavior of a mechanical body.
Skills	The students can set up balance laws and apply basics of deformation theory to specific aspects, both in applied contexts as in research contexts.
Personal Competence	
Social Competence	The students are able to develop solutions also for complex problems of solid mechanics, to present them to specialists in written form and to develop ideas further.
Autonomy	The students are able to assess their own strengths and weaknesses. They can independently and on their own identify and solve problems in the area of continuum mechanics and acquire the knowledge required to this end.
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	60 min
Assignment for the Following Curricula	Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Materials: 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 Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory

Course L1533: Continuum Mechanics	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe

Content	Continuum mechanics is a general theory to describe the effect of mechanical forces on continuous mechanical (both solid and fluid) bodies. An important part of continuum mechanics is the mathematical description of strains and stresses as well as the stress-strain response of continuous mechanical bodies. The lecture continuum mechanics builds on the foundations tought in the lecture Engineering Mechanics II (Elastostatics) but extends them significantly. While in the lecture Engineering Mechanics II (Elastostatics) the focus was by and large limited to small deformations of simple bodies under simple loading, the lecture continuum mechanics introduces a general mathematical framework to deal with arbitrarily shaped bodies under arbitrary loading undergoing very general kinds of deformations. This lecture focuses primarily on theoretical aspects of continuum mechanics but its content is key to numerous applications in modern engineering, for example, in production, automotive, and biomedical engineering. The lecture covers:
	
	• Fundamentals of tensor calculus
	  ◦ Transformation invariance
	  ◦ Tensor algebra
	  ◦ Tensor analysis
	• Kinematics
	  ◦ Motion of continuum
	  ◦ Deformation of infinitesimal line, area and volume elements
	  ◦ Material and spatial description
	  ◦ Polar decomposition
	  ◦ Spectral decomposition
	  ◦ Objectivity
	  ◦ Strain measures
	  ◦ Time derivatives
	  ▪ Partial / material time derivatives
	  ▪ Objective time rates
	  ▪ Strain and deformation rates
	  ◦ Transport theorems
	• Balance equations (global and local form)
	  ◦ Balance of mass
	  ◦ The stress state
	  ▪ Surface traction vectors
	  ▪ Cauchy's fundamental theorem
	  ▪ Stress tensors (Cauchy, 1. and 2. Piola-Kirchhoff, Kirchhoff stress tensor)
	  ◦ Balance of linear momentum
	  ◦ Balance of angular momentum
	  ◦ Balance of energy
	  ◦ Balance of entropy
	  ◦ Clausius-Duhem inequality
	• Constitutive laws
	  ◦ Constitutive assumptions
	  ◦ Fluids
	  ◦ Elastic solids
	  ▪ Hyperelasticity
	  ▪ Material symmetry
	  ◦ Elasto-plastic solids
	• Analysis
	  ◦ Initial-boundary value problems and their numerical solution

Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer

Course L1534: Continuum Mechanics Exercise	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	The exercise on Continuum Mechanics explains the theoretical content of the lecture on Continuum Mechanics by way of a series of specific example problems.
Literature	R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker I-S. Liu: Continuum Mechanics, Springer

Module M1199: Advanced Functional Materials

Courses

Title	Typ	Hrs/wk	CP
Advanced Functional Materials (L1625)	Seminar	2	6

Module Responsible	Prof. Patrick Huber
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in Materials Science, e.g. Materials Science I/II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will be able to explain the properties of advanced materials along with their applications in technology, in particular metallic, ceramic, polymeric, semiconductor, modern composite materials (biomaterials) and nanomaterials.
Skills	The students will be able to select material configurations according to the technical needs and, if necessary, to design new materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview on modern materials science, which enables them to select optimum materials combinations depending on the technical applications.
Personal Competence	
Social Competence	The students are able to present solutions to specialists and to develop ideas further.
Autonomy	The students are able to ... • assess their own strengths and weaknesses. • gather new necessary expertise by their own.
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28
Credit points	6
Course achievement	None
Examination	Presentation
Examination duration and scale	30 min
Assignment for the Following Curricula	Materials Science: Core Qualification: Compulsory Mechanical Engineering and Management: Specialisation Materials: 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 Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

Course L1625: Advanced Functional Materials

Typ	Seminar
Hrs/wk	2
CP	6
Workload in Hours	Independent Study Time 152, Study Time in Lecture 28
Lecturer	Prof. Patrick Huber, Prof. Bodo Fiedler, Prof. Gerold Schneider, Prof. Jörg Weißmüller, Prof. Kaline Pagnan Furlan, Prof. Robert Meißner
Language	DE
Cycle	WiSe
Content	1. Porous Solids - Preparation, Characterization and Functionalities 2. Fluidics with nanoporous membranes 3. Thermoplastic elastomers 4. Optimization of polymer properties by nanoparticles 5. Fiber composites in automotive 6. Modeling of materials based on quantum mechanics 7. Biomaterials
Literature	Aktuelle Publikationen aus der Fachliteratur werden während der Veranstaltung bekanntgegeben.

Module M1344: Processing of Fibre-Polymer-Composites

Courses

Title	Typ	Hrs/wk	CP
Processing of fibre-polymer-composites (L1895)	Lecture	2	3
From Molecule to Composites Part (L1516)	Project-/problem-based Learning	2	3

Module Responsible	Prof. Bodo Fiedler
Admission Requirements	None
Recommended Previous Knowledge	Knowledge in the basics of chemistry / physics / materials science
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students are able to give a summary of the technical details of the manufacturing processes composites and illustrate respective relationships. They are capable of describing and communicating relevant problems and questions using appropriate technical language. They can explain the typical process of solving practical problems and present related results.
Skills	Students can use the knowledge of fiber-reinforced composites (FRP) and its constituents (fiber / matrix) and define the necessary testing and analysis. They can explain the complex structure-property relationship and the interactions of chemical structure of the polymers, their processing with the different fiber types, including to explain neighboring contexts (e.g. sustainability, environmental protection).
Personal Competence	
Social Competence	Students are able to cooperate in small, mixed-subject groups in order to independently derive solutions to given problems in the context of civil engineering. They are able to effectively present and explain their results alone or in groups in front of a qualified audience. Students have the ability to develop alternative approaches to an engineering problem independently or in groups and discuss advantages as well as drawbacks.
Autonomy	Students are capable of independently solving mechanical engineering problems using provided literature. They are able to fill gaps in as well as extent their knowledge using the literature and other sources provided by the supervisor. Furthermore, they can meaningfully extend given problems and pragmatically solve them by means of corresponding solutions and concepts.
Workload in Hours	Independent Study Time 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	Materials Science and Engineering: Specialisation Engineering Materials: Elective Compulsory Materials Science: Specialisation Engineering Materials: Elective Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

Course L1895: Processing of fibre-polymer-composites

Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bodo Fiedler
Language	DE/EN
Cycle	SoSe
Content	Manufacturing of Composites: Hand Lay-Up; Pre-Preg; GMT, BMC; SMC, RIM; Pultrusion; Filament Winding
Literature	Åström: Manufacturing of Polymer Composites, Chapman and Hall

Course L1516: From Molecule to Composites Part	
Typ	Project-/problem-based Learning
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Bodo Fiedler
Language	DE/EN
Cycle	SoSe
Content	Students get the task in the form of a customer request for the development and production of a MTB handlebar made of fiber composites. In the task technical and normative requirements (standards) are given, all other required information come from the lectures and tutorials, and the respective documents (electronically and in conversation). The procedure is to specify in a milestone schedule and allows students to plan tasks and to work continuously. At project end, each group has a made handlebar with approved quality. In each project meeting the design (discussion of the requirements and risks) are discussed. The calculations are analyzed, evaluated and established manufacturing methods are selected. Materials are selected bar will be produced. The quality and the mechanical properties are checked. At the end of the final report created (compilation of the results for the "customers"). After the test during the "customer / supplier conversation" there is a mutual feedback-talk ("lessons learned") in order to ensure the continuous improvement.
Literature	Åström: Manufacturing of Polymer Composites, Chapman and Hall

Module M1226: Mechanical Properties

Courses

Title	Typ	Hrs/wk	CP
Mechanical Behaviour of Brittle Materials (L1661)	Lecture	2	3
Dislocation Theory of Plasticity (L1662)	Lecture	2	3

Module Responsible	Prof. Shan Shi
Admission Requirements	None
Recommended Previous Knowledge	Basics in Materials Science I/II
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	Students can explain basic principles of crystallography, statics (free body diagrams, tractions) and thermodynamics (energy minimization, energy barriers, entropy)
Skills	Students are capable of using standardized calculation methods: tensor calculations, derivatives, integrals, tensor transformations
Personal Competence	
Social Competence	Students can provide appropriate feedback and handle feedback on their own performance constructively.
Autonomy	Students are able to - assess their own strengths and weaknesses - assess their own state of learning in specific terms and to define further work steps on this basis guided by teachers. - work independently based on lectures and notes to solve problems, and to ask for help or clarifications when needed
Workload in Hours	Independent Study Time 124, Study Time in Lecture 56
Credit points	6
Course achievement	None
Examination	Written exam
Examination duration and scale	180 min
Assignment for the Following Curricula	Materials Science: Core Qualification: Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory Product Development, Materials and Production: Specialisation Production: Elective Compulsory Product Development, Materials and Production: Specialisation Materials: Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory

Course L1661: Mechanical Behaviour of Brittle Materials	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Gerold Schneider
Language	DE/EN
Cycle	SoSe
Content	**Theoretical Strength** Of a perfect crystalline material, theoretical critical shear stress **Real strength of brittle materials** Energy release reate, stress intensity factor, fracture criterion **Scattering of strength of brittle materials** Defect distribution, strength distribution, Weibull distribution **Heterogeneous materials I** Internal stresses, micro cracks, weight function, **Heterogeneous materials II** Toughening mechanisms: crack bridging, fibres **Heterogeneous materials III** Toughening mechanisms. Process zone **Testing methods to determine the fracture toughness of brittle materials** **R-curve, stable/unstable crack growth, fractography** **Thermal shock** **Subcritical crack growth)** v-K-curve, life time prediction **Kriechen** **Mechanical properties of biological materials** **Examples of use for a mechanically reliable design of ceramic components**
Literature	D R H Jones, Michael F. Ashby, Engineering Materials 1, An Introduction to Properties, Applications and Design, Elesevier D.J. Green, An introduction to the mechanical properties of ceramics", Cambridge University Press, 1998 B.R. Lawn, Fracture of Brittle Solids", Cambridge University Press, 1993 D. Munz, T. Fett, Ceramics, Springer, 2001 D.W. Richerson, Modern Ceramic Engineering, Marcel Decker, New York, 1992

Course L1662: Dislocation Theory of Plasticity	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Shan Shi
Language	EN
Cycle	SoSe
Content	This class will cover the principles of dislocation theory from a physical metallurgy perspective, providing a fundamental understanding of the relations between the strength and of crystalline solids and distributions of defects. We will review the concept of dislocations, defining terminology used, and providing an overview of important concepts (e.g. linear elasticity, stress-strain relations, and stress transformations) for theory development. We will develop the theory of dislocation plasticity through derived stress-strain fields, associated self-energies, and the induced forces on dislocations due to internal and externally applied stresses. Dislocation structure will be discussed, including core models, stacking faults, and dislocation arrays (including grain boundary descriptions). Mechanisms of dislocation multiplication and strengthening will be covered along with general principles of creep and strain rate sensitivity. Final topics will include non-FCC dislocations, emphasizing the differences in structure and corresponding implications on dislocation mobility and macroscopic mechanical behavior; and dislocations in finite volumes.
Literature	Vorlesungsskript Aktuelle Publikationen Bücher: Introduction to Dislocations, by D. Hull and D.J. Bacon Theory of Dislocations, by J.P. Hirth and J. Lothe Physical Metallurgy, by Peter Hassen

Module M1220: Interfaces and interface-dominated Materials

Courses

Title	Typ	Hrs/wk	CP
Nature's Hierarchical Materials (L1663)	Seminar	2	3
Interfaces (L1654)	Lecture	2	3

Module Responsible	Prof. Patrick Huber
Admission Requirements	None
Recommended Previous Knowledge	Basic knowledge in Materials Science, e.g. Materials Science I/II, and physical chemistry
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students will be able to explain the structural and thermodynamic properties of interfaces in comparison to the bulk systems. They will be able to describe the relevance of interfaces and physico-chemical modifications of interfaces. Moreover, they are able to outline the characteristics of biomaterials and to relate them to classical materials systems, such as metals, ceramics and polymers.
Skills	The students are able to rationalize the impact of interfaces on material properties and functionalities. Moreover, they are able to trace the peculiar properties of biomaterials to their hierarchical hybrid structure.
Personal Competence	
Social Competence	The students are able to present solutions to specialists and to develop ideas further.
Autonomy	The students are able to ... • assess their own strengths and weaknesses. • define tasks independently.
Workload in Hours	Independent Study Time 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	Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory

Course L1663: Nature's Hierarchical Materials

Typ	Seminar
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Gerold Schneider
Language	EN
Cycle	WiSe
Content	Biological materials are omnipresent in the world around us. They are the main constituents in plant and animal bodies and have a diversity of functions. A fundamental function is obviously mechanical providing protection and support for the body. But biological materials may also serve as ion reservoirs (bone is a typical example), as chemical barriers (like cell membranes), have catalytic function (such as enzymes), transfer chemical into kinetic energy (such as the muscle), etc.This lecture will focus on materials with a primarily (passive) mechanical function: cellulose tissues (such as wood), collagen tissues (such as tendon or cornea), mineralized tissues (such as bone, dentin and glass sponges). The main goal is to give an introduction to the current knowledge of the structure in these materials and how these structures relate to their (mostly mechanical) functions.
Literature	Peter Fratzl, Richard Weinkamer, Nature’s hierarchical materialsProgress, in Materials Science 52 (2007) 1263-1334 Journal publications

Course L1654: Interfaces	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Patrick Huber
Language	DE
Cycle	SoSe
Content	• Microscopic structure and thermodynamics of interfaces (gas/solid, gas/liquid, liquid/liquid, liquid/solid) • Experimental methods for the study of interfaces • Interfacial forces • wetting • surfactants, foams, bio-membranes • chemical grafting of interfaces
Literature	"Physics and Chemistry of Interfaces", K.H. Butt, K. Graf, M. Kappl, Wiley-VCH Weinheim (2006) "Interfacial Science", G.T. Barnes, I.R. Gentle, Oxford University Press (2005)

Module M1151: Materials Modeling

Courses

Title	Typ	Hrs/wk	CP
Material Modeling (L1535)	Lecture	2	3
Material Modeling (L1536)	Recitation Section (small)	2	3

Module Responsible	Prof. Christian Cyron
Admission Requirements	None
Recommended Previous Knowledge	Basics of mechanics as taught, e.g., in the modules Engineering Mechanics I and Engineering Mechanics II at TUHH (forces and moments, stress, linear strain, free-body principle, linear-elastic constitutive laws, strain energy); basics of mathematics as taught, e.g., in the modules Mathematics I and Mathematics II at TUHH
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	The students understand the theoretical foundations of anisotropic elasticity, viscoelasticity and elasto-plasticity in the realm of three-dimensional (linear) continuum mechanics. In the area of anisotropic elasticity, they know the concept of material symmetry and its application in orthotropic, transversely isotropic and isotropic materials. They understand the concept of stiffness and compliance and how both can be characterized by appropriate parameters. Moreover, the students understand viscoelasticity both in the time and frequency domain using the concepts of relaxation modulus, creep modulus, storage modulus and loss modulus. In the area of elasto-plasticity, the students know the concept of yield stress or (in higher dimensions) yield surface and of plastic potential. Additionally, the know the concepts of ideal plasticity, hardening and weakening. Moreover, they know von-Mises plasticity as a specific model of elasto-plasticity.
Skills	The students can independently identify and solve problems in the area of materials modeling and acquire the knowledge to do so. This holds in particular for the area fo anisotropically elastic, viscoelastic and elasto-plastic material behavior. In these areas, the students can independently develop models for complex material behavior. To this end, they have the ability to read and understand relevant literature and identify the relevant results reported there. Moreover, they can implement models which they developed or found in the literature in computational software (e.g., based on the finite element method) and use it for practical calculations.
Personal Competence	
Social Competence	The students are able to develop constitutive models for materials and present them to specialists. Moreover, they have the ability to discuss challenging problems of materials modeling with experts using the proper terminoloy, to identify and ask critical questions in such discussions and to identify and discuss potential caveats in models presented to them.
Autonomy	The students have the ability to independently develop abstract models that allow them to classify observed phenomena within an more general abstract framework and to predict their further evolution. Moreover, the students understand the advantages but also limitations of mathematical models and can thus independently decide when and to which extent they make sense as a basis for decisions.
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	60 min
Assignment for the Following Curricula	Materials Science: Specialisation Modeling: Elective Compulsory Mechanical Engineering and Management: Specialisation Materials: 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 Product Development, Materials and Production: Core Qualification: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory

Course L1535: Material Modeling	
Typ	Lecture
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	One of the most important questions when modeling mechanical systems in practice is how to model the behavior of the materials of their different components. In addition to simple isotropic elasticity in particular the following phenomena play key roles - anisotropy (material behavior depending on direction, e.g., in fiber-reinforced materials) - plasticity (permanent deformation due to one-time overload, e.g., in metal forming) - viscoelasticity (absorption of energy, e.g., in dampers) - creep (slow deformation under permanent load, e.g., in pipes) This lecture briefly introduces the theoretical foundations and mathematical modeling of the above phenomena. It is complemented by exercises where simple examples problems are solved by calculations and where the implementation of the content of the lecture in computer simulations is explained. It will also briefly discussed how important material parameters can be determined from experimental data.
Literature	Empfohlene Literatur / Recommended literature: 1) Dietmar Gross, Werner Hauger, Peter Wriggers, Technische Mechanik 4, Springer 2018, DOI: 10.1007/978-3-662-55694-8 2) Peter Haupt, Continuum Mechanics and Theory of Materials, Springer 2002, DOI: 10.1007/978-3-662-04775-0

Course L1536: Material Modeling	
Typ	Recitation Section (small)
Hrs/wk	2
CP	3
Workload in Hours	Independent Study Time 62, Study Time in Lecture 28
Lecturer	Prof. Christian Cyron
Language	DE
Cycle	WiSe
Content	See interlocking course
Literature	See interlocking course

Thesis

Module M-002: Master Thesis

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

Module Responsible	Professoren der TUHH
Admission Requirements	• According to General Regulations §21 (1): At least 60 credit points have to be achieved in study programme. The examinations board decides on exceptions.
Recommended Previous Knowledge	
Educational Objectives	After taking part successfully, students have reached the following learning results
Professional Competence	
Knowledge	• The students can use specialized knowledge (facts, theories, and methods) of their subject competently on specialized issues. • The students can explain in depth the relevant approaches and terminologies in one or more areas of their subject, describing current developments and taking up a critical position on them. • The students can place a research task in their subject area in its context and describe and critically assess the state of research.
Skills	The students are able: • To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question. • To apply knowledge they have acquired and methods they have learnt in the course of their studies to complex and/or incompletely defined problems in a solution-oriented way. • To develop new scientific findings in their subject area and subject them to a critical assessment.
Personal Competence	
Social Competence	Students can • Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structured way. • Deal with issues competently in an expert discussion and answer them in a manner that is appropriate to the addressees while upholding their own assessments and viewpoints convincingly.
Autonomy	Students are able: • To structure a project of their own in work packages and to work them off accordingly. • To work their way in depth into a largely unknown subject and to access the information required for them to do so. • To apply the techniques of scientific work comprehensively in research of their own.
Workload in Hours	Independent Study Time 900, Study Time in Lecture 0
Credit points	30
Course achievement	None
Examination	Thesis
Examination duration and scale	According to General Regulations
Assignment for the Following Curricula	Civil Engineering: Thesis: Compulsory Bioprocess Engineering: Thesis: Compulsory Chemical and Bioprocess Engineering: Thesis: Compulsory Computer Science: Thesis: Compulsory Data Science: Thesis: Compulsory Electrical Engineering: Thesis: Compulsory Energy Systems: Thesis: Compulsory Environmental Engineering: Thesis: Compulsory Aircraft Systems Engineering: Thesis: Compulsory Global Innovation Management: Thesis: Compulsory Computer Science in Engineering: Thesis: Compulsory Information and Communication Systems: Thesis: Compulsory Interdisciplinary Mathematics: Thesis: Compulsory International Production Management: Thesis: Compulsory International Management and Engineering: Thesis: Compulsory Joint European Master in Environmental Studies - Cities and Sustainability: Thesis: Compulsory Logistics, Infrastructure and Mobility: Thesis: Compulsory Aeronautics: Thesis: Compulsory

	Materials Science and Engineering: Thesis: Compulsory Materials Science: Thesis: Compulsory Mechanical Engineering and Management: Thesis: Compulsory Mechatronics: Thesis: Compulsory Biomedical Engineering: Thesis: Compulsory Microelectronics and Microsystems: Thesis: Compulsory Product Development, Materials and Production: Thesis: Compulsory Renewable Energies: Thesis: Compulsory Naval Architecture and Ocean Engineering: Thesis: Compulsory Ship and Offshore Technology: Thesis: Compulsory Teilstudiengang Lehramt Metalltechnik: Thesis: Compulsory Theoretical Mechanical Engineering: Thesis: Compulsory Process Engineering: Thesis: Compulsory Water and Environmental Engineering: Thesis: Compulsory Certification in Engineering & Advisory in Aviation: Thesis: Compulsory