TUHH
Hamburg
University of
Technology

# Module Manual

Master of Science (M.Sc.)

# Mechanical Engineering and Management

Cohort: Winter Term 2019

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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) | Lecture | 3 | 3 |
| Robotics: Modelling and Control (L1305) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Uwe Weltin |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals of electrical engineering<br>Broad knowledge of mechanics<br>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.<br>Students can generate trajectories in various coordinate systems.<br>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.<br>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 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Computer Science: Specialisation Intelligence Engineering: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory<br>International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory<br>Mechanical Engineering and Management: Core Qualification: Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Production: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Materials: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory |

| Course L0168: Robotics: Modelling and Control | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Uwe Weltin |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Fundamental kinematics of rigid body systems<br><br>Newton-Euler equations for manipulators<br><br>Trajectory generation<br><br>Linear and nonlinear control of robots |
| **Literature** | Craig, John J.: Introduction to Robotics Mechanics and Control, Third Edition, Prentice Hall. ISBN 0201-54361-3<br><br>Spong, Mark W.; Hutchinson, Seth; Vidyasagar, M. : Robot Modeling and Control. WILEY. ISBN 0-471-64990-2 |

| Course L1305: Robotics: Modelling and Control | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Uwe Weltin |
| **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.<br>• Students are able to explain basic theories, categories, and models in selected special areas of business management.<br>• Students are able to interrelate technical and management knowledge. |
| *Skills* | • Students are able to apply basic methods in selected areas of business management.<br>• 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 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:<br>• Selling to organizations and industrail buyers<br>• Overview of basic strategic decisions in B2B markets<br>• Relevant theories, methods and tools for operational B2B marketing (Marketing Mix)<br>• Relevant theories for intercultural communication<br>• Communication theories (verbal, non-verbal communication, role of formality, interpretation of cues such as symbols)<br>• The nature of "culture" is and its impact on human interaction<br>• Approaches for managing cultural diversity |
| *Skills* | The students will be able to apply this knowledge to:<br>• chosing appropriate cooperation forms when selling to business organizations;<br>• decide about different target markets, ways of market entry, and timingstrategies;<br>• develop appropriate value-propositions to customers;<br>• place, price and communicate industrial products with the help state-of-the-art B2B marketing tools;<br>• interpret symbols, rituals and gestures appropriately in an intercultural contex<br>• managing cultural diversity across the employees of a company<br>• communicating appropriately with customers in different regional markets<br>• apply the theoretical knowledge to business cases or real examples<br>• apply the theoretical knowledge to interpret resarch studies |
| **Personal Competence** | |
| *Social Competence* | The students will be able to<br>• have fruitful professional discussions;<br>• present and defend the results of their work in a group of students;<br>• work successfully in multi-cultural teams;<br>• 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 Technology and Innovation Management & Entrepreneurship: Core Qualification: Compulsory<br>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**<br>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.<br><br>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.<br><br>Topics<br>• The importance, specific characteristics and developments of B2B markets today<br>• Organizational buying behavior and the corporate buying process<br>• B2B marketing strategies regarding modes and time of market entry with focus on innovative industrial products<br>• Types of project-related cooperation in the B2B project business<br>• 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<br>• Marketing in complex value chains: Solving the problem of direct customers' unwillingness to adopt innovative products by directly addressing indirect customers<br><br>**Knowledge**<br><br>The students will develop a thorough understanding of:<br>• How organizations and firms buy<br>• How marketing can be performed in complex value chains<br>• Promising market and competitive strategies in B2B markets<br>• Modes of cooperation in B2B markets<br>• Marketing-Mix decisions in B2B marketing (communication, pricing, distribution)<br><br>**Skills**<br>• analyzing the advantages and disadvantages of different target market, market entry, timing and allocation strategies;<br>• identifying and systematically address relevant partners when selling to business organizations;<br>• developing context-specific market-entry and timing strategies;<br>• making appropriate decisions for the pricing and communication of industrial products;<br>• applying the theoretical knowledge to business cases or real examples<br><br>**Social Competence**<br><br>The students will be able to<br>• having fruitful professional discussions;<br>• presenting and defending the results of their work in groupwork;<br><br>**Self-reliance**<br>• acquiring knowledge in the specific context independently and to map this knowledge onto other new complex problem fields.<br><br>**Assessment**<br><br>Written examination & Class participation in interactive elements (presentations, homework) |
| **Literature** | Blythe, J., Zimmerman, A. (2005) Business-to-Business Marketing: A global perspective, London, Thomson<br><br>Monroe, K. B. (2002). Pricing: Making Profitable Decisions, 3rd Edition<br><br>Morris, M., Pitt, L., Honeycutt, E. (2001), Business-to-Business Marketing, New York, Sage Publishing, 3rd Edition<br><br>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.<br><br>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. Dr. habil. Rajnish Tiwari |
| **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.<br><br>This course focuses on inter-cultural management<br>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.<br><br>Some of the main topics covered in this course include:<br><br>• Understanding “culture” and its impact on human interaction<br>• Verbal and non-verbal communication<br>• High and low context communication<br>• Role of formality and non-formality in communication<br>• Varying interpretations of symbols, rituals & gestures<br>• Managing diversity in domestic settings |
| **Literature** | • Bartlett, C.A. / Ghoshal, S. (2002): Managing Across Borders: The Transnational Solution, 2nd edition, Boston<br>• Deresky, H. (2006): International Management: Managing Across Borders and Cultures, 3rd edition, Upper Saddle River<br>• French, R. (2010): Cross-cultural Management in Work Organisations, 2nd edition, London<br>• Hofstede, G. (2003): Culture's Consequences : Comparing Values, Behaviors, Institutions and Organizations across Nations, 2nd edition, Thousand Oaks<br>• Hofstede, G. / Hofstede, G.J. (2006): Cultures and Organizations: Software of the mind, 2nd edition, New York |

## 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 |
| Corporate Finance (L0107) | Lecture | 2 | 2 |
| Lightweight Design Practical Course (L1258) | Project-/problem-based Learning | 3 | 3 |
| Project Management Methods (L0710) | Lecture | 1 | 2 |
| Human Resource Management and Organization Design (L0108) | Lecture | 2 | 2 |
| Accounting (L1712) | Lecture | 2 | 2 |
| Accounting (L1713) | Recitation Section (large) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Dieter Krause |
| **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<br>• 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<br>• 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** | 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<br><br>Booth, Wayne C. et al. (2008); The craft of research; The University Press of Chicago, Chicago & London<br><br>Punch, Keith F. (2005); Introduction to social research – quantitative and qualitative approaches; Sage Publications, London<br><br>Bryman and Bell (2011); Business research methods; Oxford Univ. Press, Oxford<br><br>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.<br>• 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 L0107: Corporate Finance | |
|---|---|
| **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** | 60 min |
| **Lecturer** | Prof. Christian Ringle |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Introduction to corporate finance and financial management of the multinational firm;<br>• Valuation and capital budgeting (e.g., time value of money, valuing stocks and corporate bonds, discounted cash flow, net present value and other criteria, making capital investment decisions);<br>• Risk and return (e.g., measuring risk, risk and diversification, the cost of capital, dividend decisions, valuation principles such as WACC, APV, multiples and real options);<br>• Capital structure (e.g., equity financing and stocks, debt financing and corporate bonds, leasing and off-balance-sheet financing);<br>• Options and futures (e.g., call and put options, warrants and convertibles, financial risk management with derivates);<br>• Financing and financial planning of the multinational firm (e.g., financial statement analysis, short and long-term financial planning, cash and credit management);<br>• International corporate finance (e.g., foreign exchange exposure and management, international portfolio investments, international mergers and acquisitions);<br>• Comparison of Germany to other countries, especial to the USA, using e.g. case studies and exercises on internationally important topics (financial markets, companies, pension and stock markets, company risk, investments, level of debt). |
| **Literature** | Brealey, R.A./Myers, S.C./Marcus, A.J (2018): Fundamentals of Corporate Finance, 9e, New York: McGraw-Hill.<br><br>Brealey, R.A./Myers, S.C./Allen, F. (2016): Principles of Corporate Finance, 12e, New York: McGraw-Hill.<br><br>Berk, J./DeMarzo, P. (2016): Corporate Finance, 4e, Boston: Pearson.<br><br>Eun, C.S./Resnick, B.G. (2017): International Financial Management, 8e, New York: McGraw-Hill.<br><br>Robin, J.A. (2010): International Corporate Finance, New York: McGraw-Hill.<br><br>Ross, S.A./Westerfield, R.W./Jaffe, J. (2015): Corporate Finance, 11e, New York: McGraw-Hill.<br><br>Ross, S.A./Westerfield, R.W./Jaffe, J. (2017): Corporate Finance: Core Principles and Applications, 5e, New York: McGraw-Hill. |

| 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<br>• getting familiar with fibre reinforced plastics as well as lightweight design<br>• Design of a sandwich structure made of fibre reinforced plastics using finite element analysis (FEA)<br>• Determination of material properties based on sample tests<br>• manufacturing of the structure in the composite lab<br>• Testing of the developed structure<br>• Concept presentation<br>• Self-organised teamwork |
| **Literature** | • Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, 2005.<br>• Puck, A., „Festigkeitsanalsyse von Faser-Matrix-Laminaten“, Hanser, München, Wien, 1996.<br>• R&G, „Handbuch Faserverbundwerkstoffe“, Waldenbuch, 2009.<br>• VDI 2014 „Entwicklung von Bauteilen aus Faser-Kunststoff-Verbund“<br>• Ehrenstein, G. W., „Faserverbundkunststoffe“, Hanser, München, 2006.<br>• Klein, B., „Leichtbau-Konstruktion", Vieweg & Sohn, Braunschweig, 1989.<br>• Wiedemann, J., „Leichtbau Band 1: Elemente“, Springer, Berlin, Heidelberg, 1986.<br>• Wiedemann, J., „Leichtbau Band 2: Konstruktion“, Springer, Berlin, Heidelberg, 1986.<br>• Backmann, B.F., „Composite Structures, Design, Safety and Innovation”, Oxford (UK), Elsevier, 2005.<br>• Krause, D., „Leichtbau”, In: Handbuch Konstruktion, Hrsg.: Rieg, F., Steinhilper, R., München, Carl Hanser Verlag, 2012.<br>• Schulte, K., Fiedler, B., „Structure and Properties of Composite Materials”, Hamburg, TUHH - TuTech Innovation GmbH, 2005. |

| Course L0710: Project Management Methods | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Examination Form** | Klausur |
| **Examination duration and scale** | 60 min |
| **Lecturer** | Prof. Carlos Jahn |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | The course gives the participants an overview about project management as a crossover discipline. It focuses on tasks, techniques and tools which enable effective and efficient planning, implementation and controlling of projects. |
| **Literature** | Project Management Institute (2008): A guide to the project management body of knowledge (PMBOK® Guide). 4. Aufl. Newtown Square, Pa: Project Management Institute.<br><br>Haberfellner, R. et al. (2002): Systems Engineering - Methodik und Praxis. 11. Aufl. Verlag Industrielle Organisation. |

| Course L0108: Human Resource Management and Organization Design | |
|---|---|
| **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** | 60 min |
| **Lecturer** | Prof. Christian Ringle |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | The lecture addresses advanced topics of<br><br>**Organization Design & Organization Theory**<br><br>• The processes of developing organizational structures for multinational firms with special focus on (1) the balance between differentiation and integration, (2) the balance between centralization and decentralization, (3) the balance between standardization and adaptation,<br>• The adaptation of organizations and their structures to the competitive environment, with special focus on international operating organizations and global markets,<br>• Typical examples and comparison of various organizational instruments (e.g. authority and control, specialization and coordination),<br>• Introduction to established international organizational structures and network structures.<br><br>**Human Resource Management**<br><br>• Introduction to Human Resource Management from a strategic and international perspective (incl. the typical challenges of international organizations);<br>• Fundamentals of the human resource planning and recruitment in the global environment;<br>• Discussion of the advantages and disadvantages of a diverse workforce (incl. international teams);<br>• Managing performance, compensation and benefits of international corporations;<br>• Analysis and design of work, employee development, separation & retention;<br>• Case studies addressing fundamental questions in human resource management and organization design. |
| **Literature** | Dessler, G. (2020): Human Resource Management, 16e, Boston: Pearson.<br><br>Gibson, J.L./ Ivancevich, J.M./ Donnelly, J.H./ Konopaske, R. (2011): Organizations: Behavior, Structure, Processes, 14/e, Boston: McGraw-Hill.<br><br>Jones, G. R. (2012): Organizational Theory, Design, and Change, 7/e, Boston: Pearson.<br><br>Mondy, R. W. (2018): Human Resource Management, 15/e, Boston: Pearson.<br><br>Noe, R.A./ Hollenbeck, J.R./ Gerhart, B./ Wright, P.M. (2010): Human Resource Management: Gaining a Competitive Advantage, 7/e, New York: McGraw-Hill. |

| 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** | Dr. Uwe Kagelmann |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | **Course objective:**<br>To provide a theoretical and a practical insight into the area of financial and management accounting.<br><br>**Approach:**<br>Illustration of theoretical concepts combined with case studies and business examples.<br><br>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.<br><br>I. Introduction to Cost Terms and Concepts<br><br>II. Standard Costing and Variance Analysis<br><br>III. Financial Accounting and Reporting (Financial Statement, Income Statement, Cash Flow)<br><br>IV. Information for Decision Making<br><br>V. Performance Management: Planning, Budgeting & Forecasting |
| **Literature** | **Literature: Business Accounting and Finance 3e**<br><br>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** | Dr. Uwe Kagelmann |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## 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 |
| Corporate Finance (L0107) | Lecture | 2 | 2 |
| Lightweight Design Practical Course (L1258) | Project-/problem-based Learning | 3 | 3 |
| Project Management Methods (L0710) | Lecture | 1 | 2 |
| Human Resource Management and Organization Design (L0108) | Lecture | 2 | 2 |
| Accounting (L1712) | Lecture | 2 | 2 |
| Accounting (L1713) | Recitation Section (large) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Dieter Krause |
| **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<br>• 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<br>• 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** | 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<br><br>Booth, Wayne C. et al. (2008); The craft of research; The University Press of Chicago, Chicago & London<br><br>Punch, Keith F. (2005); Introduction to social research – quantitative and qualitative approaches; Sage Publications, London<br><br>Bryman and Bell (2011); Business research methods; Oxford Univ. Press, Oxford<br><br>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.<br>• also laws on contracts, construction, labor, patents, companies |
| **Literature** | As per Stud.IP. |

| Course L0107: Corporate Finance | |
|---|---|
| **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** | 60 min |
| **Lecturer** | Prof. Christian Ringle |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Introduction to corporate finance and financial management of the multinational firm;<br>• Valuation and capital budgeting (e.g., time value of money, valuing stocks and corporate bonds, discounted cash flow, net present value and other criteria, making capital investment decisions);<br>• Risk and return (e.g., measuring risk, risk and diversification, the cost of capital, dividend decisions, valuation principles such as WACC, APV, multiples and real options);<br>• Capital structure (e.g., equity financing and stocks, debt financing and corporate bonds, leasing and off-balance-sheet financing);<br>• Options and futures (e.g., call and put options, warrants and convertibles, financial risk management with derivates);<br>• Financing and financial planning of the multinational firm (e.g., financial statement analysis, short and long-term financial planning, cash and credit management);<br>• International corporate finance (e.g., foreign exchange exposure and management, international portfolio investments, international mergers and acquisitions);<br>• Comparison of Germany to other countries, especial to the USA, using e.g. case studies and exercises on internationally important topics (financial markets, companies, pension and stock markets, company risk, investments, level of debt). |
| **Literature** | Brealey, R.A./Myers, S.C./Marcus, A.J (2018): Fundamentals of Corporate Finance, 9e, New York: McGraw-Hill.<br><br>Brealey, R.A./Myers, S.C./Allen, F. (2016): Principles of Corporate Finance, 12e, New York: McGraw-Hill.<br><br>Berk, J./DeMarzo, P. (2016): Corporate Finance, 4e, Boston: Pearson.<br><br>Eun, C.S./Resnick, B.G. (2017): International Financial Management, 8e, New York: McGraw-Hill.<br><br>Robin, J.A. (2010): International Corporate Finance, New York: McGraw-Hill.<br><br>Ross, S.A./Westerfield, R.W./Jaffe, J. (2015): Corporate Finance, 11e, New York: McGraw-Hill.<br><br>Ross, S.A./Westerfield, R.W./Jaffe, J. (2017): Corporate Finance: Core Principles and Applications, 5e, New York: McGraw-Hill. |

| 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<br>• getting familiar with fibre reinforced plastics as well as lightweight design<br>• Design of a sandwich structure made of fibre reinforced plastics using finite element analysis (FEA)<br>• Determination of material properties based on sample tests<br>• manufacturing of the structure in the composite lab<br>• Testing of the developed structure<br>• Concept presentation<br>• Self-organised teamwork |
| **Literature** | • Schürmann, H., „Konstruieren mit Faser-Kunststoff-Verbunden“, Springer, Berlin, 2005.<br>• Puck, A., „Festigkeitsanalsyse von Faser-Matrix-Laminaten“, Hanser, München, Wien, 1996.<br>• R&G, „Handbuch Faserverbundwerkstoffe“, Waldenbuch, 2009.<br>• VDI 2014 „Entwicklung von Bauteilen aus Faser-Kunststoff-Verbund“<br>• Ehrenstein, G. W., „Faserverbundkunststoffe“, Hanser, München, 2006.<br>• Klein, B., „Leichtbau-Konstruktion", Vieweg & Sohn, Braunschweig, 1989.<br>• Wiedemann, J., „Leichtbau Band 1: Elemente“, Springer, Berlin, Heidelberg, 1986.<br>• Wiedemann, J., „Leichtbau Band 2: Konstruktion“, Springer, Berlin, Heidelberg, 1986.<br>• Backmann, B.F., „Composite Structures, Design, Safety and Innovation”, Oxford (UK), Elsevier, 2005.<br>• Krause, D., „Leichtbau”, In: Handbuch Konstruktion, Hrsg.: Rieg, F., Steinhilper, R., München, Carl Hanser Verlag, 2012.<br>• Schulte, K., Fiedler, B., „Structure and Properties of Composite Materials”, Hamburg, TUHH - TuTech Innovation GmbH, 2005. |

| Course L0710: Project Management Methods | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Examination Form** | Klausur |
| **Examination duration and scale** | 60 min |
| **Lecturer** | Prof. Carlos Jahn |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | The course gives the participants an overview about project management as a crossover discipline. It focuses on tasks, techniques and tools which enable effective and efficient planning, implementation and controlling of projects. |
| **Literature** | Project Management Institute (2008): A guide to the project management body of knowledge (PMBOK® Guide). 4. Aufl. Newtown Square, Pa: Project Management Institute.<br><br>Haberfellner, R. et al. (2002): Systems Engineering - Methodik und Praxis. 11. Aufl. Verlag Industrielle Organisation. |

| Course L0108: Human Resource Management and Organization Design | |
|---|---|
| **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** | 60 min |
| **Lecturer** | Prof. Christian Ringle |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | The lecture addresses advanced topics of<br><br>**Organization Design & Organization Theory**<br><br>• The processes of developing organizational structures for multinational firms with special focus on (1) the balance between differentiation and integration, (2) the balance between centralization and decentralization, (3) the balance between standardization and adaptation,<br>• The adaptation of organizations and their structures to the competitive environment, with special focus on international operating organizations and global markets,<br>• Typical examples and comparison of various organizational instruments (e.g. authority and control, specialization and coordination),<br>• Introduction to established international organizational structures and network structures.<br><br>**Human Resource Management**<br><br>• Introduction to Human Resource Management from a strategic and international perspective (incl. the typical challenges of international organizations);<br>• Fundamentals of the human resource planning and recruitment in the global environment;<br>• Discussion of the advantages and disadvantages of a diverse workforce (incl. international teams);<br>• Managing performance, compensation and benefits of international corporations;<br>• Analysis and design of work, employee development, separation & retention;<br>• Case studies addressing fundamental questions in human resource management and organization design. |
| **Literature** | Dessler, G. (2020): Human Resource Management, 16e, Boston: Pearson.<br><br>Gibson, J.L./ Ivancevich, J.M./ Donnelly, J.H./ Konopaske, R. (2011): Organizations: Behavior, Structure, Processes, 14/e, Boston: McGraw-Hill.<br><br>Jones, G. R. (2012): Organizational Theory, Design, and Change, 7/e, Boston: Pearson.<br><br>Mondy, R. W. (2018): Human Resource Management, 15/e, Boston: Pearson.<br><br>Noe, R.A./ Hollenbeck, J.R./ Gerhart, B./ Wright, P.M. (2010): Human Resource Management: Gaining a Competitive Advantage, 7/e, New York: McGraw-Hill. |

| 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** | Dr. Uwe Kagelmann |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | **Course objective:**<br>To provide a theoretical and a practical insight into the area of financial and management accounting.<br><br>**Approach:**<br>Illustration of theoretical concepts combined with case studies and business examples.<br><br>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.<br><br>I. Introduction to Cost Terms and Concepts<br><br>II. Standard Costing and Variance Analysis<br><br>III. Financial Accounting and Reporting (Financial Statement, Income Statement, Cash Flow)<br><br>IV. Information for Decision Making<br><br>V. Performance Management: Planning, Budgeting & Forecasting |
| **Literature** | **Literature: Business Accounting and Finance 3e**<br><br>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** | Dr. Uwe Kagelmann |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## 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)**<br><br>imparts skills that, in view of the TUHH's training profile, professional engineering studies require but are not able to cover fully. Self-reliance, self-management, collaboration and professional and personnel management competences. The department implements these training objectives in its **teaching architecture**, in its **teaching and learning arrangements**, in **teaching areas** and by means of teaching offerings in which students can qualify by opting for **specific competences** and a **competence level** at the Bachelor's or Master's level. The teaching offerings are pooled in two different catalogues for nontechnical complementary courses.<br><br>**The Learning Architecture**<br><br>consists of a cross-disciplinarily study offering. The centrally designed teaching offering ensures that courses in the nontechnical academic programms follow the specific profiling of TUHH degree courses.<br><br>The learning architecture demands and trains independent educational planning as regards the individual development of competences. It also provides orientation knowledge in the form of "profiles".<br><br>The subjects that can be studied in parallel throughout the student's entire study program - if need be, it can be studied in one to two semesters. In view of the adaptation problems that individuals commonly face in their first semesters after making the transition from school to university and in order to encourage individually planned semesters abroad, there is no obligation to study these subjects in one or two specific semesters during the course of studies.<br><br>**Teaching and Learning Arrangements**<br><br>provide for students, separated into B.Sc. and M.Sc., to learn with and from each other across semesters. The challenge of dealing with interdisciplinarity and a variety of stages of learning in courses are part of the learning architecture and are deliberately encouraged in specific courses.<br><br>**Fields of Teaching**<br><br>are based on research findings from the academic disciplines cultural studies, social studies, arts, historical studies, 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.<br><br>The fields of teaching are augmented by soft skills offers and a foreign language offer. Here, the focus is on encouraging goal-oriented communication skills, e.g. the skills required by outgoing engineers in international and intercultural situations.<br><br>**The Competence Level**<br><br>of the courses offered in this area is different as regards the basic training objective in the Bachelor's and Master's fields. These differences are reflected in the practical examples used, in content topics that refer to different professional application contexts, and in the higher scientific and theoretical level of abstraction in the B.Sc.<br><br>This is also reflected in the different quality of soft skills, which relate to the different team positions and different group leadership functions of Bachelor's and Master's graduates in their future working life.<br><br>**Specialized Competence (Knowledge)**<br><br>Students can<br><br>• explain specialized areas in context of the relevant non-technical disciplines,<br>• outline basic theories, categories, terminology, models, concepts or artistic techniques in the disciplines represented in the learning area,<br>• different specialist disciplines relate to their own discipline and differentiate it as well as make connections,<br>• sketch the basic outlines of how scientific disciplines, paradigms, models, instruments, methods and forms of representation in the specialized sciences are subject to individual and socio-cultural interpretation and historicity,<br>• Can communicate in a foreign language in a manner appropriate to the subject. |
| *Skills* | **Professional Competence (Skills)**<br><br>In selected sub-areas students can<br><br>• apply basic and specific methods of the said scientific disciplines,<br>• aquestion a specific technical phenomena, models, theories from the viewpoint of another, aforementioned specialist discipline,<br>• to handle simple and advanced questions in aforementioned scientific disciplines in a sucsessful manner,<br>• justify their decisions on forms of organization and application in practical questions in contexts that go beyond the technical relationship to the subject. |

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

| **Courses** |
|---|
| **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** | Dr. Stephan Lippert |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | - Mechanical parts and basic operations of manufacturing techniques<br>- Basic knowledge in mathematics, physics, and statics<br>- Mechanics I (statics, mechanics of materials) and mechanics II (hydrostatics, kinematics, dynamics)<br>- 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<br>- General knowledge of the finite element method in combination with a basic theoretical and methodology basis<br>- 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** | Dr. Stephan Lippert, Prof. Dieter Krause, Prof. Claus Emmelmann |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | **Part 1: Computer aided design (Prof. Dr.-Ing. D. Krause)**<br>• Introduction to integrated product development<br>• 3D-CAD-systems and CAD-interfaces<br>• Introduction to PDM-systems<br>• Additional computer aided engineering/simulation tools (FEA, DMU, VR)<br>**Part 2: Introduction to the Finite Element Method (Dr.-Ing. S. Lippert)**<br>• General overview on the finite element method<br>• Displacement method<br>• Isoparametric elements<br>• Numerical integration<br>• Applications<br>• Programming of elements (Matlab, hands-on sessions)<br>**Part 3: Structural Optimization Methods (Prof. Dr.-Ing. C. Emmelmann)**<br>• Introduction to structural optimization theory<br>• Fields of application for structural optimization and commercial software tools<br>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<br>Bathe, K.-J.: Finite element procedures, Prentice Hall<br>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** | Dr. Stephan Lippert, Prof. Dieter Krause, 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** | Prof. Dieter Krause |
| **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<br>• 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<br>• They are able to plan their work and their procedure<br>• 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<br>• They can discuss their work with colleagues and respond adequately to critique<br>• 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: Fibre-polymer-composites

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Structure and properties of fibre-polymer-composites (L1894) | Lecture | 2 | 3 |
| Design with fibre-polymer-composites (L1893) | Lecture | 2 | 3 |

| | |
|---|---|
| **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.<br><br>They can explain the complex relationships structure-property relationship and<br><br>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<br><br>• using standardized calculation methods in a given context to mechanical properties (modulus, strength) to calculate and evaluate the different materials.<br>• approximate sizing using the network theory of the structural elements implement and evaluate.<br>• selecting appropriate solutions for mechanical recycling problems and sizing example stiffness, corrosion resistance. |
| **Personal Competence** | |
| *Social Competence* | Students can<br><br>• arrive at funded work results in heterogenius groups and document them.<br>• provide appropriate feedback and handle feedback on their own performance constructively. |
| *Autonomy* | Students are able to<br><br>- assess their own strengths and weaknesses.<br><br>- assess their own state of learning in specific terms and to define further work steps on this basis.<br><br>- assess possible consequences of their professional activity. |
| **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** | Energy Systems: Core Qualification: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory<br>Materials Science: Specialisation Engineering Materials: Elective Compulsory<br>Mechanical Engineering and Management: Core Qualification: Compulsory<br>Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Production: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Materials: Compulsory<br>Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory<br>Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory<br>Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: 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<br>- Development of composite materials<br>- Mechanical and physical properties<br>- Mechanics of Composite Materials<br>- Laminate theory<br>- Test methods<br>- Non destructive testing<br>- Failure mechanisms<br>- Theoretical models for the prediction of properties<br>- Application |
| **Literature** | Hall, Clyne: Introduction to Composite materials, Cambridge University Press<br>Daniel, Ishai: Engineering Mechanics of Composites Materials, Oxford University Press<br>Mallick: Fibre-Reinforced Composites, Marcel Deckker, New York |

| Course L1893: Design with 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** | Designing with Composites: Laminate Theory; Failure Criteria; Design of Pipes and Shafts; Sandwich Structures; Notches; Joining Techniques; Compression Loading; Examples |
| **Literature** | Konstruieren mit Kunststoffen, Gunter Erhard , Hanser Verlag |

## 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.<br>• 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) | Project-/problem-based Learning | 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:<br>• International R&D-Management<br>• Technology Timing Strategies<br>  ◦ Technology Strategies and Lifecycle Management (I/II)<br>  ◦ Technology Intelligence and Planning<br>• Technology Portfolio Management<br>  ◦ Technology Portfolio Methodology<br>  ◦ Technology Acquisition and Exploitation<br>  ◦ IP Management<br>• Organizing Technology Development<br>  ◦ Technology Organization & Management<br>  ◦ Technology Funding & Controlling |
| *Skills* | The course aims to:<br>• Develop an understanding of the importance of Technology Management - on a national as well as international level<br>• Equip students with an understanding of important elements of Technology Management (strategic, operational, organizational and process-related aspects)<br>• Foster a strategic orientation to problem-solving within the innovation process as well as Technology Management and its importance for corporate strategy<br>• Clarify activities of Technology Management (e.g. technology sourcing, maintenance and exploitation)<br>• 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:<br>• Basic concepts, models and tools, relevant to the management of technology, R&D and innovation<br>• Innovation as a process (steps, activities and results) |
| **Personal Competence** | |
| *Social Competence* | • Interact within a team<br>• Raise awareness for globabl issues |
| *Autonomy* | • Gain access to knowledge sources<br>• Discuss recent research debates in the context of Technology and Innovation Management<br>• Develop presentation skills<br>• 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<br>Global Technology and Innovation Management & Entrepreneurship: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Management: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory |

| | |
|---|---|
| | Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Compulsory |

| **Course L0849: Technology Management** | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **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.<br><br>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 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<br>• Basic understanding of business administration principles (strategic planning, decision theory, project management, international business)<br>• Bachelor-level Marketing Knowledge (Marketing Instruments, Market and Competitor Strategies, Basics of Buying Behavior)<br>• Unerstanding the differences beweetn B2B and B2C marketing<br>• Understanding of the importance of managing innovation in global industrial markets<br>• 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<br>• Specific characteristics in the marketing of innovative poroducts and services<br>• Approaches for analyzing the current market situation and the future market development<br>• The gathering of information about future customer needs and requirements<br>• Concepts and approaches to integrate lead users and their needs into product and service development processes<br>• Approaches and tools for ensuring customer-orientation in the development of new products and innovative services<br>• Marketing mix elements that take into consideration the specific requirements and challenges of innovative products and services<br>• Pricing methods for new products and services<br>• The organization of complex sales forces and personal selling<br>• Communication concepts and instruments for new products and services |
| *Skills* | Based on the acquired knowledge students will be able to:<br>• Design and to evaluate decisions regarding marketing and innovation strategies<br>• Analyze markets by applying market and technology portfolios<br>• Conduct forecasts and develop compelling scenarios as a basis for strategic planning<br>• Translate customer needs into concepts, prototypes and marketable offers and successfully apply advanced methods for customer-oriented product and service development<br>• Use adequate methods to foster efficient diffusion of innovative products and services<br>• Choose suitable pricing strategies and communication activities for innovations<br>• Make strategic sales decisions for products and services (i.e. selection of sales channels)<br>• Apply methods of sales force management (i.e. customer value analysis) |
| **Personal Competence** | |
| *Social Competence* | The students will be able to<br>• have fruitful discussions and exchange arguments<br>• develop original results in a group<br>• present results in a clear and concise way<br>• carry out respectful team work |
| *Autonomy* | The students will be able to<br>• Acquire knowledge independently in the specific context and to map this knowledge on other new complex problem fields.<br>• 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<br>International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Management: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>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<br>• Innovation and service marketing (importance of innovative products and services, model, objectives and examples of innovation marketing, characteristics of services, challenges of service marketing)<br>II. Methods and approaches of strategic marketing planning<br>• patterns of industrial development, patent and technology portfolios<br>III. Strategic foresight and scenario analysis<br>• objectives and challenges of strategic foresight, scenario analysis, Delphi method<br>IV. User innovations<br>• Role of users in the innovation process, user communities, user innovation toolkits, lead users analysis<br>V. Customer-oriented Product and Service Engineering<br>• Conjoint Analysis, Kano, QFD, Morphological Analysis, Blueprinting<br>VII. Pricing<br>• Basics of Pricing, Value-based pricing, Pricing models<br>VIII. Sales Management<br>• Basics of Sales Management, Assessing Customer Value, Planning Customer Visits<br>IX. Communications<br>• 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).**<br>Crawford, M., Di Benedetto, A. (2008). New products management, 9th edition, McGrw Hill, Boston et al., 2008<br>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.<br>Hair, J. F., Bush, R. P., Ortinau, D. J. (2009). Marketing research. 4th edition, Boston et al., McGraw Hill<br>Tidd; J. & Hull, Frank M. (Editors) (2007) Service Innovation, London<br>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 M0978: Mobility of Goods and Logistics Systems

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Prof. Heike Flämig |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Introduction to Logistics and Mobility<br>• Foundations of Management<br>• 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...<br>• give definitions of system theory, (international) transport chains and logistics in the context of supply chain management<br>• explain trends and strategies for mobility of goods and logistics<br>• describe elements of integrated and multi-modal transport chains and their advantages and disadvantages<br>• deduce impacts of management decisions on logistics system and traffic system and explain how stakeholders influence them<br>• 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...<br>• Design intermodal transport chains and logistic concepts<br>• apply the commodity chain theory and case study analysis<br>• evaluate different international transport chains<br>• cope with differences in cultures that influence international transport chains |
| **Personal Competence** | |
| *Social Competence* | Students are able to...<br>• develop a feeling of social responsibility for their future jobs<br>• give constructive feedback to others about their presentation skills<br>• 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<br>Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Management: Elective Compulsory |

| Course L1165: 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, Christiane Waßmann-Krohn |
| **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.<br>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.<br><br>1. A conceptual systems model<br>2. Elements of integrated and multi-modal transportation chains<br>3. interaction of transport and traffic, demand and supply on different layers of the transport system<br>4. Global Issues in Supply Chain Management<br>5. Global Players and networks<br>6. Logistics and corporate social responsibility (CSR)<br>7. Methods and data for assessment of international transport chains<br>8. Influence of cultural aspects on international transport chains<br>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<br><br>Schieck, Arno: Internationale Logistik: Objekte, Prozesse und Infrastrukturen grenzüberschreitender Güterströme, München, 2009<br><br>BLOECH, J., IHDE, G. B. (1997) Vahlens Großes Logistiklexikon, München, Verlag C.H. Beck<br><br>IHDE, G. B. (1991) Transport, Verkehr, Logistik, München, Verlag Franz Vahlen, 2. völlig überarbeitete und erweiterte Auflage<br><br>NUHN, H., HESSE, M. (2006) Verkehrsgeographie, Paderborn, München, Wien, Zürich, Verlage Ferdinand Schöningh<br><br>PFOHL, H.-C. (2000) Logistiksysteme - Betriebswirtschaftliche Grundlagen, Berlin, Heidelberg, New York, Springer-Verlag, 6. Auflage |

| 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, Christiane Waßmann-Krohn |
| **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<br><br>Schieck, Arno: Internationale Logistik: Objekte, Prozesse und Infrastrukturen grenzüberschreitender Güterströme, München, 2009 |

## 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...<br>• describe complex and interrelated constructs in the fields of marketing, management of organizations, strategic and human resource management;<br>• discuss underlying theories of research models;<br>• explain strategies of research problem analysis;<br>• describe the functioning and use of quantitative research methods;<br>• discuss strengths and weaknesses of quantitative research methods. |
| *Skills* | The students will be able to...<br>• deal with complex empirical problems;<br>• collect empirical data, apply multivariate techniques to the data collected using standard software, and critically evaluate and interpret results gained;<br>• work with common statistical software programs (like R, Smart PLS and SPSS);<br>• address research questions with quantitative research methods. |
| **Personal Competence** | |
| *Social Competence* | The students will be able to...<br>• have fruitful professional discussions;<br>• present and defend the results of their work;<br>• communicate and collaborate successfully and respectfully with others in teams. |
| *Autonomy* | The students will be able to...<br>• acquire knowledge in a specific context independently and to map this knowledge onto other new complex problem fields,<br>• 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.<br><br>The course involves three parts:<br><br>• The first part of the course focuses on an introduction of quantitative research methods,<br>• 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,<br>• 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:<br><br>• Dalgaard, P. (2008). Introductory statistics with R. Springer Science & Business Media.<br>• 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.<br>• 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 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 | 2 | 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...<br>• describe an internationally active company;<br>• describe complex and interrelated business processes along the supply chain;<br>• present important aspects of the project management of enterprise resource planning software implementations;<br>• name rules and processes for the implementation of business processes in SAP;<br>• explain the functioning and use of enterprise resource planning software along the supply chain;<br>• conduct business processes in SAP on their own;<br>• present the integrative role of enterprise resource planning systems. |
| *Skills* | The students are able to...<br>• map the design of business processes along the supply chain of a firm;<br>• implement business processes in an enterprise resource planning software;<br>• use an internationally used enterprise resource planning software in a daily routine;<br>• 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...<br>• direct fruitful and professional discussions;<br>• work in teams on exercises;<br>• present and defend results of their work;<br>• 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 152, Study Time in Lecture 28 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: Yes, Bonus: None, Form: Written elaboration<br>Compulsory: Yes, Bonus: None, Form: Presentation |
| **Examination** | Written elaboration |
| **Examination duration and scale** | 12 pages per student; 3 months |
| **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** | 2 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 152, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Ringle |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | The course involves two main parts:<br><br>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.<br><br>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:<br><br>• Agrawal, A. (2009): Customizing Materials Management Processes in SAP ERP Operations, Galileo Press: Boston.<br>• Arif, N./Tauseef, S. (2010): Integrating SAP ERP Financials, Galileo Press: Boston.<br>• Chudy, M./Castedo, L. (2015): Sales and Distribution in SAP ERP - Practical Guide, Galileo Press: Boston.<br>• Dickersback, J. T./Keller, G. (2010): Production Planning and Control with SAP ERP, 2e, Galileo Press: Boston.<br>• Franz, M. (2014): Project Management with SAP Project System, 4e, Galileo Press: Boston.<br>• Hoppe, M./Gulyassy, F. (2009): Materials Planning with SAP, Galileo Press: Boston.<br>• Veeriah, N. (2011): Customizing Financial Accounting in SAP, Galileo Press: Boston.<br>• Veeriah, N. (2011): Financial Accounting in SAP, Galileo Press: Boston. |

## Module M1034: Technology Entrepreneuship

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Creation of Business Opportunities (L1280) | Project-/problem-based Learning | 3 | 4 |
| Entrepreneurship (L1279) | Lecture | 2 | 2 |

| | |
|---|---|
| **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):<br>• develop a working knowledge and understanding of the entrepreneurial perspective<br>• understand the difference between a good idea and scalable business opportunity<br>• understand the process of taking a technology idea and finding a high-potential commercial opportunity<br>• understand the components of business models<br>• understand the components of business opportunity assessment and business plans |
| *Skills* | • Fertigkeiten (subject-related skills):<br>◦ identify and define business opportunities<br>◦ assess and validate entrepreneurial opportunities<br>◦ create and verify a business model of how to sell and market an entrepreneurial opportunity<br>◦ formulate and test business model assumptions and hypotheses<br>◦ conduct customer and expert interviews regarding business opportunities<br>◦ prepare business opportunity assessment<br>◦ create and verify a plan for gathering resources such as talent and capital<br>◦ pitch a business opportunity to your classmates and the teaching team |
| **Personal Competence** | |
| *Social Competence* | Sozialkompetenz (Social Competence):<br>• team work<br>• communication and presentation<br>• give and take critical comments<br>• engaging in fruitful discussions |
| *Autonomy* | Selbständigkeit (Autonomy):<br>• autonomous work and time management<br>• project management<br>• 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<br>International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Core Qualification: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Management: Elective Compulsory |

| Course L1280: Creation of Business Opportunities | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, 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.<br><br>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.<br>Upon completion of this course, students will be able to:<br>· Apply a modern innovation toolkit relevant in both the corporate & startup world<br>· Analyze given business opportunities in terms of its constituent elements<br>· Design new business models by gathering and combining relevant ideas, facts and information<br>· Evaluate business opportunities and derive judgment about next steps & decisions<br>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.<br>Student teams give three presentations and submit them with backup analyses. Grading scheme:<br>· Startup discovery presentation after 5 weeks: 30%<br>· Startup validation presentation after 10 weeks: 30%<br>· Final startup pitches after 13 weeks: 40% |
| **Literature** | • Blank, S. & Dorf, B. (2012). The startup owner's manual.<br>• Gans, J. & Stern, S. (2016). Entrepreneurial Strategy.<br>• Osterwalder, A. & Yves, P. (2010). Business model generation.<br>• Maurya, A. (2012). Running lean: Iterate from plan A to a plan that works.<br>• Maurya, A. (2016). Scaling lean: Mastering the Key Metrics for Startup Growth.<br>• Wilcox, J. (2016). FOCUS Framework: How to Find Product-Market Fit. |

| Course L1279: Entrepreneurship | |
|---|---|
| **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** | 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.<br><br>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.<br>Upon completion of this course, students will be able to:<br>· Apply a modern innovation toolkit relevant in both the corporate & startup world<br>· Analyze given business opportunities in terms of its constituent elements<br>· Design new business models by gathering and combining relevant ideas, facts and information<br>· Evaluate business opportunities and derive judgment about next steps & decisions<br>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.<br>Student teams give three presentations and submit them with backup analyses. Grading scheme:<br>· Startup discovery presentation after 5 weeks: 30%<br>· Startup validation presentation after 10 weeks: 30%<br>· Final startup pitches after 13 weeks: 40% |
| **Literature** | • Blank, S. & Dorf, B. (2012). The startup owner's manual.<br>• Gans, J. & Stern, S. (2016). Entrepreneurial Strategy.<br>• Osterwalder, A. & Yves, P. (2010). Business model generation.<br>• Maurya, A. (2012). Running lean: Iterate from plan A to a plan that works.<br>• Maurya, A. (2016). Scaling lean: Mastering the Key Metrics for Startup Growth.<br>• Wilcox, J. (2016). FOCUS Framework: How to Find Product-Market Fit. |

## Module M0750: Economics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| International Economics (L0700) | Lecture | 2 | 4 |
| Main Theoretical and Political Concepts (L0641) | Lecture | 2 | 2 |

**Module Responsible**: Prof. Kathrin Fischer

**Admission Requirements**: None

**Recommended Previous Knowledge**: Basic Knowledge in Economics.
Relevant previous knowledge is taught and tested by an online 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
- different economic policies (trade, monetary, fiscal and exchange rate policy) and their effects on the home and foreign economies

*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
- expectations hypothesis
- the functioning of an economy (including money market, financial and goods markets, labor market)
- links between economies
- the effects of economic policies (trade, monetary, fiscal and exchange rate policies)
- to understand advanced economic models.

**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
- 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 reconile them with the studied theoretical concepts.
- to design, analyze and evaluate micro- and macroeconomic policies against the background of different models.

**Workload in Hours**: Independent Study Time 124, Study Time in Lecture 56

**Credit points**: 6

**Course achievement**

| Compulsory | Bonus | Form | Description |
|---|---|---|---|
| Yes | 5 % | Excercises | |

**Examination**: Written exam

**Examination duration and scale**: 2 hours

**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** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Annette Olbrisch-Ziegler |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • International Trade Theory and Policy:<br>  ◦ Comparative Advantage, the Ricardian Model<br>  ◦ The Heckscher-Ohlin Model<br>  ◦ The Standard Trade Model<br>  ◦ Intrasectoral Trade<br>  ◦ International Trade Policy<br>• Open Economy Macroeconomics<br>  ◦ The Foreign Exchange Market<br>  ◦ Determinants of Prices, Interest Rates, Exchange Rates, Output in the Short Run<br>  ◦ Determinants of Prices, Interest Rates, Exchange Rates, Output in the Long Run<br>  ◦ Monetary and Fiscal and Exchange Rate Policies in Open Economies in the Long and the Short Run |
| **Literature** | Krugman/Obstfeld: International Economics, Longman, 9th ed. 2011<br><br>Mankiw/Taylor: Economics, South-Western 2008<br><br>Documents and notes handed out during the lecture. |

| 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. Annette Olbrisch-Ziegler |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • **Introduction: Ten Principles of Economics**<br>• Microeconomics:<br>  ◦ Theory of the Household<br>  ◦ Theory of the Firm<br>  ◦ Competitive Markets in Equilibrium<br>  ◦ Market Failure: Monopoly and External Effects<br>  ◦ Government Policies<br>• Macroeconomics:<br>  ◦ A Nation’s Real Income and Production<br>  ◦ The Real Economy in the Long Run: Capital and Labour Market<br>  ◦ Money and Prices in the Long Run<br>  ◦ Aggregate Demand and Supply: Short-Run Economic Fluctuations<br>  ◦ Monetary and Fiscal Policy in the Short and the Long Run |
| **Literature** | Mankiw/Taylor: Economics, South-Western 2008<br><br>Pindyck/Rubinfeld: Microeconomics, Prentice Hall International , 7$^{th}$ ed. 2010<br><br>Documents and notes handed out during the lecture. |

## Module M0543: Management, Organization and Human Resource Management

**Courses**

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

**Module Responsible**: Prof. Christian Ringle

**Admission Requirements**: None

**Recommended Previous Knowledge**: Module “Human Resource Management and Organizational Design”

Knowledge of

- The study of organizations and organizational theories;
- The processes of developing organizational structures for multinational firms;
- Analysis and design of work;
- Strategic management of the human resource function in international business;
- Human resource planning and recruitment in the global environment;
- Managing performance measurement, compensation and benefits of international corporations;
- Employee development;
- Employee separation and retention.

**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, strategic alliances) to compete in global business;
- map the need of organizational changes in light of new business lines, strategies, altering employee attitudes and international competition;
- describe the business process management and reengineering techniques in order to consolidate resources to meet international customer requirements profitably;
- explain the meaning and importance of managing human resources in multinational companies and its relation to organizational designs and strategies;
- explain the personnel recruitment and talent management strategies (e.g., personnel planning, employee testing, developing) throughout national and international organizations;
- explain the models and approaches for appropriately measuring employee relations (e.g., job satisfaction models) including the development and estimation of causal models;
- present the models and research methodologies used to forecast personnel requirements (e.g., forecasting procedures, linear programming, neural networks).

*Skills* The students are able to...

- collect empirical data (e.g., data on business processes and data on employee relations, such as job satisfaction), apply business process management and multivariate techniques to the data collected using standard software, and critically evaluate and interpret results gained in order to, for instance, optimize business processes (e.g. in terms of business efficiency) and develop new global human resource strategies;
- critically rethink theoretical concepts and gain analytical ability in organization and human resource management (e.g., critically evaluate the process of acquiring, training, appraising and compensating employees in light of health, safety and fairness concerns in international environments);
- map their theoretical understanding of international human resources and business management on actual economic problems and to evaluate how these components affect other fields;
- use their practical knowledge of the analytical toolset to successfully tackle the management challenges in organization and human resource management in internationally acting companies;
- to model and analyze business processes of firms using the essential techniques and standard software (with an emphasis on managing international business processes);
- present their results in written and oral form.

**Personal Competence**

*Social Competence* The students are able to...

- have discussions with international experts in the fields of organization and human resource management;
- respectfully work in teams;
- strengthen their intercultural personal competencies by problem based learning-elements.

*Autonomy* The students are able to...

- independently acquire knowledge in the specific context and to map this knowledge on other or new complex problem

| | |
|---|---|
| | fields;<br>• improve their overall management skills (starting with a structured analysis of the business problem, via developing suitable solutions, to appropriately communicating/presenting solutions developed). |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** **Bonus** **Form** **Description**<br>Yes 20 % Presentation |
| **Examination** | Written elaboration |
| **Examination duration and scale** | 12 Pages |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Management: Elective Compulsory |

| **Course L0110: 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 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:<br>• Human Resource Management: aging workforce, e-human resource management, generation X, Y, Z, human resource metrics/ analytics, recruitment/ selection/ hiring<br>• Organisation: employee voice, exploration/ exploitation, networks, organisational identity, trust measurement<br>• Management: change management, corporate social responsibility, firm performance measurement, gender, innovation management |
| **Literature** | The students will be provided with selected journal articles.<br>Bernardin, H.J. (2006): Human Resource Management: An Experiential Approach, 4e, New York: McGraw-Hill.<br>Cascio, W. (2015): Managing Human Resources: Productivity, Quality of Work Life, Profits, revised edition, New York: McGraw-Hill.<br>French, W./Bell, C.H./Zawacki, R.A. (2004): Organization Development and Transformation: Managing Effective Change, 6e, Chicago: McGraw-Hill.<br>Hitt, M.A./Ireland, R.D./Hoskisson, R.E. (2014): Strategic Management: Competitiveness and Globalization, 11e, Ohio: Cengage Learning.<br>Lynch, R. (2015): Strategic Management, 7e, Harlow: Prentice Hall. |

| Course L0111: 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:<br>• Human Resource Management: aging workforce, e-human resource management, generation X, Y, Z, human resource metrics/ analytics, recruitment/ selection/ hiring<br>• Organisation: employee voice, exploration/ exploitation, networks, organisational identity, trust measurement<br>• Management: change management, corporate social responsibility, firm performance measurement, gender, innovation management |
| **Literature** | The students will be provided with selected journal articles.<br>Bernardin, H.J. (2006): Human Resource Management: An Experiential Approach, 4e, New York: McGraw-Hill.<br>Cascio, W. (2015): Managing Human Resources: Productivity, Quality of Work Life, Profits, revised edition, New York: McGraw-Hill.<br>French, W./Bell, C.H./Zawacki, R.A. (2004): Organization Development and Transformation: Managing Effective Change, 6e, Chicago: McGraw-Hill.<br>Hitt, M.A./Ireland, R.D./Hoskisson, R.E. (2014): Strategic Management: Competitiveness and Globalization, 11e, Ohio: Cengage Learning.<br>Lynch, R. (2015): Strategic Management, 7e, Harlow: Prentice Hall. |

## Module M1035: Corporate Entrepreneurship & Growth

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Corporate Entrepreneurship in the Digital Age (L1281) | Seminar | 3 | 4 |
| Entrepreneurial Finance (L1282) | Seminar | 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):<br>• understand similarities and differences between corporate and start-up entrepreneurship<br>• recognize the distinct nature and specific elements of corporate entrepreneurship in the context of established and international organizations<br>• understand the different forms of corporate entrepreneurship<br>• understand their own managerial styles, attitudes and preferences for corporate versus start-up entrepreneurship<br>• understand the pros and cons of different valuation methods<br>• understand the interests of venture capital funds<br>• understand the pros and cons of different growth and exit options |
| *Skills* | Fertigkeiten (subject-related skills):<br>• be able to apply an entrepreneurial approach to operations of a department or functional area within established organizations<br>• assess the environment within established companies in terms of support or constraints for entrepreneurship<br>• identify creative ways to overcome obstacles to entrepreneurship in established companies<br>• be able to formulate corporate objectives and strategies that support entrepreneurial behavior<br>• evaluate entrepreneurial opportunities in contexts of established corporations<br>• develop concepts for new businesses out of established company contexts<br>• value entrepreneurial opportunities in financial terms<br>• apply different valuation methods<br>• evaluate the attractiveness of financial contracts<br>• design VC term sheets<br>• design employee contracts in terms of financial compensation<br>• design financial contracts and conduct financial negotiations<br>• assess and justify possible growth and exit options |
| **Personal Competence** | |
| *Social Competence* | Sozialkompetenz (Social Competence):<br>• team work<br>• communication and presentation<br>• give and take critical comments<br>• engaging in fruitful discussions |
| *Autonomy* | Selbständigkeit (Autonomy):<br>• autonomous work and time management<br>• project management<br>• analytical skills |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: Yes; Bonus: 20 %; Form: Group discussion; Description: |
| **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<br>Global Technology and Innovation Management & Entrepreneurship: Core Qualification: Elective Compulsory<br>International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Management: Elective Compulsory |

### Course L1281: Corporate Entrepreneurship in the Digital Age

| | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 3 |

| | |
|---|---|
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Dr. Hannes Lampe |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | This is a 4 ECTS course as part of the module “Corporate Entrepreneurship & Growth”. Emerging paradigms of digital technology, such as industrial internet of things, blockchain, artificial intelligence, digital fabrication and 3D printing, are fundamentally transforming the competitive landscape and the nature of many companies in a wide range of industries. Where digital technologies become critical to the development of new products, services and business models, incumbent corporations in traditional industries suddenly face entirely new competition from purely digital players. Building a corporate capability to master digital innovation becomes a key success factor to establish and maintain market leadership. This course places students into the role of corporate managers, who need to understand the strategic implications of new digital technology, identify organizational strengths and barriers to (re-) act, design new business models that may fundamentally clash with existing ones, and organize broader digital transformation initiatives. We will draw upon recent international scientific findings from the context of digital corporate venturing. Upon completion of this course, students will be able to:<br>· Derive industry-specific implications of digital technologies for value creation and capture.<br>· Identify organizational sources of corporate (non-) responsiveness to digital opportunities.<br>· Contribute to the design and implementation of digitally enhanced business models.<br>· Evaluate options of organizational transformation by corporate venturing as well as open platforms and ecosystems.<br>· Contribute to organization and leadership of corporate-wide digital transformation initiatives.<br>Course language is English. In this course, value is created interactively, that means it mainly consists of student presentations and group discussions, structured and moderated by the instructors. This in turn requires that everyone has prepared the relevant materials in advance of each session. Please devote significant time to do so! All the great ideas relevant to this course topic cannot be found in a single textbook. Therefore, we have curated an up-to-date and colourful mix of materials in two different kinds: (1) academic & managerial papers, and (2) case studies. Please refer to the detailed course schedule for the assignment of paper presentations and case memos to specific participants. For your paper presentations you may also include additional references, whereas the case memos should only be based on the cases. Even if you are not assigned a specific paper or case, you should have prepared core materials to participate in the discussion. For the common team project, we cooperate with real companies from the Hamburg metropolitan region to contribute to their strategic intent of embracing new digital technology.<br>Student assessment will be based on four aspects with the following grading scheme:<br>· 20%: Participation in class discussions on papers and case studies.<br>· 20%: One paper presentation of 20 minutes length plus 10 minutes discussion: 20%.<br>· 20%: Two case memos (2 pages) that summarize in bullet points your answers to assigned questions for two case studies.<br>· 40%: Final project on a real digital transformation project delivered as 30 minutes presentation plus 15 minutes discussion by teams of four students. |
| **Literature** | · Agrawal, Ajay, Joshua Gans and Avi Goldfarb. “The Simple Economics of Machine Intelligence”. Harvard Business Review, November (2016).<br>· Amit, Raphael, and Christoph Zott. "Creating Value Through Business Model Innovation" MIT Sloan Management Review 53.3 (2012): 41-49.<br>· Birkinshaw, Julian, Alexander Zimmermann, and Sebastain Raisch. "How Do Firms Adapt to Discontinuous Change?" California Management Review, 58.4 (2016): 36-58.<br>· Bower, Joseph L., and Clayton M. Christensen. "Disruptive technologies: Catching the wave." Harvard Business Review, 73.1 (1995): 43-53.<br>· Campbell, A., Birkinshaw, J., Morrison, A., & van Basten Batenburg, R. "The future of corporate venturing: companies undertake venturing for a variety of reasons." MIT Sloan Management Review 45.1 (2003): 30-38.<br>· Casadesus-Masanell, Ramon, and Joan E. Ricart. "How to Design A Winning Business Model" Harvard Business Review January-February (2011): 1-9.<br>· Chakravorti, Bhaskar. "A Note on Corporate Entrepreneurship: Challenge or Opportunity?" HBS Case: 9-810-145 (2010).<br>· Charitou, Constantinos D., and Constantinos C. Markides. "Responses to disruptive strategic innovation." MIT Sloan Management Review, 44.2 (2002): 55-64.<br>· Chesbrough, Henry W. "Making Sense of Corporate Venture Capital" Harvard Business Review, March (2002): 4-11.<br>· Christensen, Clayton M. and Stephen P. Kaufman."Assessing Your Organization’s Capabilities: Resources, Processes, and Priorities" Module Note: HBS 9-607-014 (2008).<br>· Christensen, Clayton M., and Michael Overdorf. "Meeting the Challenge of Disruptive Change" Harvard Business Review, March-April (2009): 1-10.<br>· D'Aveni, Richard. “The 3-D Printing revolution.” Harvard Business Review, May (2015): 40-48.<br>· Gans, Joshua. "The other disruption." Harvard Business Review, March (2016): 80-84.<br>· Iansiti, Marco, and Karim R. Lakhani. "Digital Ubiquity: How Connections, Sensors, and Data Are Revolutionizing Business." Harvard Business Review, November (2014): 1-11.<br>· Johnson, Mark W., Clayton M. Christensen, and Henning Kagermann. "Reinventing Your Business Model" Harvard Business Review December (2008): 2-10.<br>· Kavadias, Stelios, Kostas Ladas, and Christoph Loch. "The Transformative Business Model: How to tell if you have one." Harvard Business Review, October (2016): 91-98.<br>· King, Andrew A., and Baljir Baatartogtokh. "How Useful Is the Theory of Disruptive Innovation?." MIT Sloan Management Review, 57.1 (2015): 77-90.<br>· Ransbotham, Sam. “Blockchain Data Storage May (Soon) Change Your Business Model”. Sloan Management Review, April (2016).<br>· Shih, Willy. "Competency-Destroying Technology Transitions: Why the Transition to Digital Is Particularly Challenging" Note: HBS 9-613-024 (2013).<br>· Tapscott, Don, and Alex Tapscott. “The Impact of the Blockchain Goes Beyond Financial Services”. Harvard Business |

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| | Review, May (2016).<br>· Vermeulen, Freek. "How Acquisitions Can Revitalize Companies." MIT Sloan Management Review, 46.4 (2005): 45-51.<br>· Wolcott, Robert C., and Michael J. Lippitz. "The four models of corporate entrepreneurship." MIT Sloan Management Review, 49.1 (2007): 75-82.<br>· Zilis, Shivon, and James Cham. “The Competitive Landscape for Machine Intelligence”. Harvard Business Review, November (2016). |

| **Course L1282: Entrepreneurial Finance** | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Hannes Lampe |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | This course examines the elements of entrepreneurial finance, focusing on technology-based start-up ventures and the early stages of company development. The course addresses key questions relevant to both startup and corporate entrepreneurs: 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? This course will focus on the finance principles related to the risk & return of venture capital, the valuation of high growth companies, the capital structure specific to venture capital-backed companies, and investment decisions under uncertainty. Three main topics will be covered:<br><br>(1) New business opportunity valuation: Most time will be devoted to the understanding and application of tools to valuate early stage business opportunities and high-growth companies versus mature companies. Standard tools for financial and liquidity planning as well as discounted cash flow valuation will be applied to startup situations. Furthermore, the venture capital method, analysis of comparables and the real options approach to valuation are introduced.<br><br>(2) Financing and employment contracts: We will discuss the main sources of financing that entrepreneurs can choose from. Particular emphasis will be put on venture capital funds and their fund raising process. The design of financial contracts will be analyzed in terms of addressing information and incentive problems in uncertain environments. Employment contracts will be motivated as a compensation device to attract and retain key employees.<br><br>(3) Growth and exit strategies: We will discuss entrepreneurs’ option to grow or exit. Liquidity events are considered such as initial public offering, sale or merger as compared to independent growth as a private company. We also examine later stage options such as mezzanine financing and buy-outs and the specifics of international growth.<br><br>Guest lecturers will present the latest trends in these areas. The ideal audience for the course will be students who are interested in technology entrepreneurship, either at startups or within larger organizations. It is also useful for those pursuing careers in corporate finance or valuation consulting. |
| **Literature** | Metrick, Andrew, and Ayako Yasuda. Venture Capital and the Finance of Innovation. Wiley, 2010.<br>Leach, J., and Ronald Melicher. Entrepreneurial finance. Cengage Learning, 2011.<br>Selected cases will be made available during class. |

## 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** | Compulsory: Yes; Bonus: None; Form: Written elaboration; Description: |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes, 28 questions |
| **Assignment for the Following Curricula** | Mechanical Engineering and Management: Specialisation Management: Elective Compulsory<br>Mechatronics: Specialisation System Design: Elective Compulsory<br>Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory<br>Biomedical Engineering: Core Qualification: Compulsory<br>Product Development, Materials and Production: Core Qualification: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>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:<br>• Chi square test<br>• Simple regression and correlation<br>• Multiple regression and correlation<br>• One way analysis of variance<br>• Two way analysis of variance<br>• Discriminant analysis<br>• Analysis of categorial data<br>• Chossing the appropriate statistical method<br>• 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) | Project-/problem-based Learning | 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:<br>• Product Planning<br>  ◦ Process<br>  ◦ Methods<br>• Design thinking<br>  ◦ Process<br>  ◦ Methods<br>  ◦ User integration |
| *Skills* | Students will gain deep insights into:<br>• Product Planning<br>  ◦ Process-related aspects<br>  ◦ Organisational-related aspects<br>  ◦ Human-Ressource related aspects<br>  ◦ Working-tools, methods and instruments<br>  ◦ |
| **Personal Competence** | |
| *Social Competence* | • Interact within a team<br>• Raise awareness for globabl issues |
| *Autonomy* | • Gain access to knowledge sources<br>• Interpret complex cases<br>• 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** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | Global Innovation Management: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Management: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Production: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Materials: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory |

| Course L0851: Product Planning | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **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<br><br>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.:<br>• Systematic scanning of markets for innovation opportunities<br>• Understanding strengths/weakness and specific core competences of a firm as platforms for innovation<br>• Exploring relevant sources for innovation (customers, suppliers, Lead Users, etc.)<br>• Developing ideas for radical innovation, relying on the creativeness of employees, using techniques to stimulate creativity and creating a stimulating environment<br>• Transferring ideas for innovation into feasible concepts which have a high market attractively<br><br>Voluntary presentations in the third hour (articles / case studies)<br><br>- Guest lectures by researchers<br><br>- Lecture on Sustainability with frequent reference to current research<br><br>- Permanent reference to current research<br><br>Examination:<br><br>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<br>• Linear Algebra<br>• 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. |
| *Skills* | Students are able to denote methods of Vibration Theory and develop them further. |
| **Personal Competence** | |
| *Social Competence* | Students can reach working results also in groups. |
| *Autonomy* | 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<br>International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Product Development, Materials and Production: Core Qualification: Compulsory<br>Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory<br>Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: 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 Oscillations and Waves. |
| **Literature** | K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen. Springer Verlag, 2013. |

## 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<br>• Linear Algebra<br>• 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. |
| *Skills* | Students are able to apply existing methods and procesures of Nonlinear Dynamics and to develop novel methods and procedures. |
| **Personal Competence** | |
| *Social Competence* | Students can reach working results also in groups. |
| *Autonomy* | Students are able to approach given research tasks individually and 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: Specialisation Aircraft Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory<br>Mechatronics: Specialisation System Design: Elective Compulsory<br>Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Product Development, Materials and Production: Core Qualification: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>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. |
| **Literature** | S. Strogatz: Nonlinear Dynamics and Chaos. Perseus, 2013. |

## 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** | Prof. Herbert Werner |
| **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<br>• They can explain the system properties controllability and observability, and their relationship to state feedback and state estimation, respectively<br>• They can explain the significance of a minimal realisation<br>• They can explain observer-based state feedback and how it can be used to achieve tracking and disturbance rejection<br>• They can extend all of the above to multi-input multi-output systems<br>• They can explain the z-transform and its relationship with the Laplace Transform<br>• They can explain state space models and transfer function models of discrete-time systems<br>• 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<br>• 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<br>• They can assess controllability and observability and construct minimal realisations<br>• They can design LQG controllers for multivariable plants<br>• 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<br>• They can identify transfer function models and state space models of dynamic systems from experimental data<br>• 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.<br><br>They can assess their knowledge in weekly on-line tests and thereby control their learning progress. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Electrical Engineering: Core Qualification: Compulsory<br>Energy Systems: Core Qualification: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Aircraft Systems: Compulsory<br>Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory<br>Computational Science and Engineering: Specialisation II. Engineering Science: Elective Compulsory<br>International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Product Development, Materials and Production: Core Qualification: Elective Compulsory<br>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** | Prof. Herbert Werner |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | State space methods (single-input single-output)<br><br>• State space models and transfer functions, state feedback<br>• Coordinate basis, similarity transformations<br>• Solutions of state equations, matrix exponentials, Caley-Hamilton Theorem<br>• Controllability and pole placement<br>• State estimation, observability, Kalman decomposition<br>• Observer-based state feedback control, reference tracking<br>• Transmission zeros<br>• Optimal pole placement, symmetric root locus<br>Multi-input multi-output systems<br>• Transfer function matrices, state space models of multivariable systems, Gilbert realization<br>• Poles and zeros of multivariable systems, minimal realization<br>• Closed-loop stability<br>• Pole placement for multivariable systems, LQR design, Kalman filter<br><br>Digital Control<br>• Discrete-time systems: difference equations and z-transform<br>• Discrete-time state space models, sampled data systems, poles and zeros<br>• Frequency response of sampled data systems, choice of sampling rate<br><br>System identification and model order reduction<br>• Least squares estimation, ARX models, persistent excitation<br>• Identification of state space models, subspace identification<br>• Balanced realization and model order reduction<br><br>Case study<br>• Modelling and multivariable control of a process evaporator using Matlab and Simulink<br>Software tools<br>• Matlab/Simulink |
| **Literature** | • Werner, H., Lecture Notes „Control Systems Theory and Design“<br>• T. Kailath "Linear Systems", Prentice Hall, 1980<br>• K.J. Astrom, B. Wittenmark "Computer Controlled Systems" Prentice Hall, 1997<br>• 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** | Prof. Herbert Werner |
| **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** | Prof. Manfred Kasper |
| **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<br>International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory<br>Mechatronics: Specialisation System Design: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Microelectronics and Microsystems: Core Qualification: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>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. rer. nat. Thomas Kusserow |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Object and goal of MEMS<br>Scaling Rules<br>Lithography<br>Film deposition<br>Structuring and etching<br>Energy conversion and force generation<br>Electromagnetic Actuators<br>Reluctance motors<br>Piezoelectric actuators, bi-metal-actuator<br>Transducer principles<br>Signal detection and signal processing<br>Mechanical and physical sensors<br>Acceleration sensor, pressure sensor<br>Sensor arrays<br>System integration<br>Yield, test and reliability |
| **Literature** | M. Kasper: Mikrosystementwurf, Springer (2000)<br>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. rer. nat. Thomas Kusserow |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Examples of MEMS components<br>Layout consideration<br>Electric, thermal and mechanical behaviour<br>Design aspects |
| **Literature** | Wird in der Veranstaltung bekannt gegeben |

## 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<br>• Signals and Systems<br>• Fundamentals of signal and system theory as well as random processes.<br>• 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. |
| *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<br>Computational Science and Engineering: Specialisation II. Engineering Science: Elective Compulsory<br>Information and Communication Systems: Specialisation Communication Systems, Focus Signal Processing: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory<br>Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory<br>Microelectronics and Microsystems: Specialisation Communication and Signal Processing: Elective Compulsory<br>Microelectronics and Microsystems: Specialisation Communication and Signal Processing: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Numerics 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:<br>  ◦ Discrete-time Fourier Transform (DTFT)<br>  ◦ Discrete Fourier-Transform (DFT), Fast Fourier Transform (FFT)<br>  ◦ Z-Transform<br>• Correspondence of continuous-time and discrete-time signals, sampling, sampling theorem<br>• Fast convolution, Overlap-Add-Method, Overlap-Save-Method<br>• Fundamental structures and basic types of digital filters<br>• Characterization of digital filters using pole-zero plots, important properties of digital filters<br>• Quantization effects<br>• Design of linear-phase filters<br>• Fundamentals of stochastic signal processing and adaptive filters<br>  ◦ MMSE criterion<br>  ◦ Wiener Filter<br>  ◦ LMS- and RLS-algorithm<br>• Traditional and parametric methods of spectrum estimation |
| **Literature** | K.-D. Kammeyer, K. Kroschel: Digitale Signalverarbeitung. Vieweg Teubner.<br>V. Oppenheim, R. W. Schafer, J. R. Buck: Zeitdiskrete Signalverarbeitung. Pearson StudiumA. V.<br>W. Hess: Digitale Filter. Teubner.<br>Oppenheim, R. W. Schafer: Digital signal processing. Prentice Hall.<br>S. Haykin:  Adaptive flter theory.<br>L. B. Jackson: Digital filters and signal processing.  Kluwer.<br>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<br>principles of automata<br>principles of algorithms and data structures<br>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 work in teams to solve problems. |
| *Autonomy* | The students can reflect their knowledge and document the results of their work. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | Compulsory: No; Bonus: 10 %; Form: Excercises; Description: |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation Chemical Process Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory<br>Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory<br>Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory<br>International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory<br>Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory<br>Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory<br>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<br>- properties of processes, modeling using automata and Petri-nets<br>- design considerations for processes (mutex, deadlock avoidance, liveness)<br>- optimal scheduling for processes<br>- optimal decisions when planning manufacturing systems, decisions under uncertainty<br>- software design and software architectures for automation, PLCs |
| **Literature** | J. Lunze: „Automatisierungstechnik“, Oldenbourg Verlag, 2012<br>Reisig: Petrinetze: Modellierungstechnik, Analysemethoden, Fallstudien; Vieweg+Teubner 2010<br>Hrúz, Zhou: Modeling and Control of Discrete-event Dynamic Systems; Springer 2007<br>Li, Zhou: Deadlock Resolution in Automated Manufacturing Systems, Springer 2009<br>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 M0913: Mixed-signal Circuit Design

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Mixed-signal Circuit Design (L0764) | Lecture | 2 | 3 |
| Mixed-signal Circuit Design (L1063) | Project-/problem-based Learning | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Matthias Kuhl |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Advanced knowledge of analog or digital MOS devices and circuits |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can explain the descriptive parameters of mixed-signal systems<br>• Students can explain various architectures of analog-to-digital and digital-to-analog converters<br>• Students are able to explain the fundamental limitations of different analog-to-digital and digital-to-analog converters |
| *Skills* | • Students can derive the fundamental limitations of different analog-to-digital and digital-to-analog converters<br>• Students can select the most suitable architecture for a specific mixed-signal task<br>• Students can describe complex mixed-signal systems by their functional blocks.<br>• Students can calculate the specifications of mixed-signal circuits |
| **Personal Competence** | |
| *Social Competence* | • Students can team up with one or several partners who may have different professional backgrounds<br>• Students are able to work by their own or in small groups for solving problems and answer scientific questions. |
| *Autonomy* | • Students are able to assess their knowledge in a realistic manner.<br>• Students are able to draw scenarios for estimation of the impact of an increase of data vs. an increase of energy on the future lifestyle of the society. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes; **Bonus** None; **Form** Subject theoretical and practical work; **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | Electrical Engineering: Specialisation Nanoelectronics and Microsystems Technology: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory<br>Microelectronics and Microsystems: Specialisation Microelectronics Complements: Elective Compulsory |

### Course L0764: Mixed-signal Circuit Design

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Matthias Kuhl |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Differences between analog and digital filtering of electrical signals<br>• Quantization error and its consideration in electrical circuits<br>• Architectures of state-of-the-art digital-to-analog converters<br>• Architectures of state-of-the-art analog-to-digital converters<br>• Differentiation between Nyquist and oversampling converters<br>• noise in ADCs and DACs |
| **Literature** | • R. J. Baker, „CMOS-Circuit Design, Layout, and Simulation“, Wiley & Sons, IEEE Press, 2010<br>• B. Razavi,"Design of Analog CMOS Integrated Circuits", McGraw-Hill Education Ltd, 2000 |

| Course L1063: Mixed-signal Circuit Design | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Matthias Kuhl |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0552: 3D Computer Vision

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| 3D Computer Vision (L0129) | Lecture | 2 | 3 |
| 3D Computer Vision (L0130) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Rolf-Rainer Grigat |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Knowlege of the modules Digital Image Analysis and Pattern Recognition and Data Compression are used in the practical task<br>• Linear Algebra (including PCA, SVD), nonlinear optimization (Levenberg-Marquardt), basics of stochastics and basics of Matlab are required and cannot be explained in detail during the lecture. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can explain and describe the field of projective geometry. |
| *Skills* | Students are capable of<br>• Implementing an exemplary 3D or volumetric analysis task<br>• Using highly sophisticated methods and procedures of the subject area<br>• Identifying problems and<br>• Developing and implementing creative solution suggestions.<br>With assistance from the teacher students are able to link the contents of the three subject areas (modules)<br>• Digital Image Analysis<br>• Pattern Recognition and Data Compression<br>and<br>• 3D Computer Vision<br>in practical assignments. |
| **Personal Competence** | |
| *Social Competence* | Students can collaborate in a small team on the practical realization and testing of a system to reconstruct a three-dimensional scene or to evaluate volume data sets. |
| *Autonomy* | Students are able to solve simple tasks independently with reference to the contents of the lectures and the exercise sets.<br>Students are able to solve detailed problems independently with the aid of the tutorial's programming task. |
| **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 Minutes, Content of Lecture and materials in StudIP |
| **Assignment for the Following Curricula** | Computer Science: Specialisation Intelligence Engineering: Elective Compulsory<br>Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory<br>Information and Communication Systems: Specialisation Communication Systems, Focus Signal Processing: Elective Compulsory<br>Information and Communication Systems: Specialisation Secure and Dependable IT Systems, Focus Software and Signal Processing: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Mechatronics: Elective Compulsory<br>Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory<br>Microelectronics and Microsystems: Specialisation Communication and Signal Processing: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory |

| Course L0129: 3D Computer Vision | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Rolf-Rainer Grigat |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Projective Geometry and Transformations in 2D und 3D in homogeneous coordinates<br>• Projection matrix, calibration<br>• Epipolar Geometry, fundamental and essential matrices, weak calibration, 5 point algorithm<br>• Homographies 2D and 3D<br>• Trifocal Tensor<br>• Correspondence search |
| **Literature** | • **Skriptum Grigat/Wenzel**<br>• Hartley, Zisserman: Multiple View Geometry in Computer Vision. Cambridge 2003. |

| Course L0130: 3D Computer Vision | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Rolf-Rainer Grigat |
| **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<br>+ give an overview of the different (h, p, hp) finite element procedures.<br>+ explain high-order finite element procedures.<br>+ 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<br>+ apply high-order finite elements to problems of structural mechanics.<br>+ select for a given problem of structural mechanics a suitable finite element procedure.<br>+ critically judge results of high-order finite elements.<br>+ transfer their knowledge of high-order finite elements to new problems. |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>+ solve problems in heterogeneous groups and to document the corresponding results. |
| *Autonomy* | Students are able to<br>+ assess their knowledge by means of exercises and E-Learning.<br>+ acquaint themselves with the necessary knowledge to solve research oriented tasks. |
| **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** | Energy Systems: Core Qualification: Elective Compulsory<br>International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory<br>Materials Science: Specialisation Modeling: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Product Development and Production: Elective Compulsory<br>Mechatronics: Technical Complementary Course: Elective Compulsory<br>Product Development, Materials and Production: Core Qualification: Elective Compulsory<br>Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>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<br>2. Motivation<br>3. Hierarchic shape functions<br>4. Mapping functions<br>5. Computation of element matrices, assembly, constraint enforcement and solution<br>6. Convergence characteristics<br>7. Mechanical models and finite elements for thin-walled structures<br>8. Computation of thin-walled structures<br>9. Error estimation and hp-adaptivity<br>10. High-order fictitious domain methods |
| **Literature** | [1] Alexander Düster, High-Order FEM, Lecture Notes, Technische Universität Hamburg-Harburg, 164 pages, 2014<br>[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<br>• Fundamental of Material Science<br>• 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:<br>• give an overview of Additive Manufacturing Technologies, namely<br>• describe basics of Laser Technologies<br>• discuss laser Additive Manufacturing, specifically<br>• design Guidelines for Additive Manufacturing<br>• describe the Digital Process Chain for Additive Manufacturing<br>• discuss Quality Assurance for Additive Manufacturing<br>• describe Product Development for Additive Manufacturing |
| *Skills* | The students will be able to:<br>• give an overview of Potential and Challenges of Additive Manufacturing Technologies<br>• show that Additive Manufacturing offers new possibilities for product development<br>• show major differences between Additive Manufacturing and conventional manufacturing technologies<br>• apply basic skills to develop and design Additive Manufacturing parts<br>• design and build own Additive Manufacturing parts |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>• interact within a team<br>• organize workload in a team |
| *Autonomy* | Students are able to<br>• develop and optimize a product with limited resources, based on defined requirements<br>• 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.<br>**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.<br><br>**This seminar is part of the Module Rapid Production and cannot be chosen separately.** |
| **Literature** | Will be announced during the course |

## Module M0807: Boundary Element Methods

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Boundary Element Methods (L0523) | Lecture | 2 | 3 |
| Boundary Element Methods (L0524) | Recitation Section (large) | 2 | 3 |

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

| Course L0523: Boundary Element Methods | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Otto von Estorff |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | - Boundary value problems<br>- Integral equations<br>- Fundamental Solutions<br>- Element formulations<br>- Numerical integration<br>- Solving systems of equations (statics, dynamics)<br>- Special BEM formulations<br>- Coupling of FEM and BEM<br><br>- Hands-on Sessions (programming of BE routines)<br>- Applications |
| **Literature** | Gaul, L.; Fiedler, Ch. (1997): Methode der Randelemente in Statik und Dynamik. Vieweg, Braunschweig, Wiesbaden<br>Bathe, K.-J. (2000): Finite-Elemente-Methoden. Springer Verlag, Berlin |

| Course L0524: Boundary Element Methods | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Otto von Estorff |
| **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<br><br>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<br><br>• 3D printing based on fused deposition modeling,<br>• printer setup and hardware components,<br>• software and CAD data preparation,<br>• and process parameters and quality aspects. |
| *Skills* | The students will be able to<br><br>• prepare CAD models for 3D printing,<br>• calibrate and operate a 3D printer,<br>• conduct designed experiments,<br>• and find optimal printing parameters. |
| **Personal Competence** | |
| *Social Competence* | The students will be able to<br><br>• coordinate work in a team,<br>• set up, monitor and adapt a project plan,<br>• share information with team members,<br>• deal with different personal knowledge backgrounds,<br>• and handle team conflicts. |
| *Autonomy* | Without external support the students will be able to<br><br>• do literature research,<br>• organize work according to a schedule,<br>• conduct experiments,<br>• 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:<br><br>· Preparation of CAD models for 3D printing,<br><br>· Design of Experiments for 3D-printing<br><br>· Hands-on operation of 3D printer<br><br>· 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:<br>• beam sources,<br>• transport and manipulation of Laser beams,<br>• and laser Safety.<br><br>They can also describe applications of laser systems in material processing, namely:<br>• primary forming,<br>• marking,<br>• cutting,<br>• joining,<br>• and surface treatment.<br><br>They can also explain the material science of technically relevant metals as for example<br>• carbon steels,<br>• micro alloyed steels<br>• low- and high-alloyed steels,<br>• stainless steels,<br>• aluminium alloys,<br>• and magnesium alloys. |
| *Skills* | After successful completion of this course, students should be able to<br>• give an overview on current laser technology,<br>• classify its applications in today’s manufacturing processes,<br>• evaluate economical and quality aspects,<br>• 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<br>• Laser beam sources: CO2-, Nd:YAG-, Fiber- and Diodelasers<br>• Laser system technology: beam forming, beam guidance systems, beam motion and beam control<br>• Laser-based manufacturing technologies: generation, marking, cutting, joining, surface treatment<br>• Quality assurance and economical aspects of laser material processing<br>• Markets and Applications of laser technology<br>• Student group exercises |
| **Literature** | • Hügel, H. , T. Graf: Laser in der Fertigung : Strahlquellen, Systeme, Fertigungsverfahren, 3. Aufl., Vieweg + Teubner Wiesbaden 2014.<br>• Eichler, J., Eichler. H. J.: Laser: Bauformen, Strahlführung, Anwendungen, 7. Aufl., Springer-Verlag Berlin Heidelberg 2010.<br>• Steen W. M.; Mazumder J.: Laser material processing, 4th Edition, Springer-Verlag London 2010.<br>• J.C. Ion: Laser processing of engineering materials: principles, procedure and industrial applications, Elsevier Butterworth-Heinemann 2005.<br>• 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** | Steels:<br>• Fundamentals of steels<br>• Carbon steels: phase diagram, transformation behaviour, technical heat treatments<br>• Low and high alloyed steels: influence of alloying elements on transformation and carbides<br>• Micro alloyed steels<br>• Corrosion and scaling resistant steels : Classification, composition and microstructure, properties and applications<br>Aluminium alloys:<br>• Alloy systems and groups<br>• Non-age-hardenable Al-alloys: Processing and microstructure, Mechanical properties and applications<br>• Age-hardenable Al-alloys: Processing and microstructure, Mechanical properties and applications<br>Titanium alloys<br>• Introduction into titanium materials, alloy systems and groups<br>• Processing, microstructure and properties<br>• Applications<br>Magnesium alloys<br>• Introduction into magnesium materials, Alloy systems and groups<br>• Cast alloys, processing, microstructure and properties<br>Wrought alloys, processing, microstructure and properties |
| **Literature** | • George Krauss, Steels: Processing, Structure, and Performance, 978-0-87170-817-5, 2006,<br>• Hans Berns, Werner Theisen, Ferrous Materials: Steel and Cast Iron, 2008. http://dx.doi.org/10.1007/978-3-540-71848-2<br>• C. W. Wegst, Stahlschlüssel = Key to steel = La Clé des aciers = Chiave dell'acciaio = Liave del acero ISBN/ISSN: 3922599095<br>• Bruno C., De Cooman / John G. Speer: Fundamentals of Steel Product Physical Metallurgy, 2011, 642 S.<br>• Harry Chandler, Steel Metallurgy for the Non-Metallurgist 0-87170-652-0, 2006, 84 S.<br>• Catrin Kammer, Aluminium Taschenbuch 1, Grundlagen und Werkstoffe, Beuth,16. Auflage 2009. 784 S., ISBN 978-3-410-22028-2<br>• 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<br>• Catrin Kammer, Aluminium Taschenbuch 3, Weiterverarbeitung und Anwendung, Beuith,17. Auflage 2014. 892 S., ISBN 978-3-410-22311-5<br>• G. Lütjering, J.C. Williams: Titanium, 2nd ed., Springer, Berlin, Heidelberg, 2007, ISBN 978-3-540-71397<br>• Magnesium - Alloys and Technologies, K. U. Kainer (Hrsg.), Wiley-VCH, Weinheim 2003, ISBN 3-527-30570-x<br>• 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 linear continuum mechanics as taught, e.g., in the module Mechanics II (forces and moments, stress, linear strain, free-body principle, linear-elastic constitutive laws, strain energy). |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can explain the fundamental concepts to calculate the mechanical behavior of materials. |
| *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, 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** | 45 min |
| **Assignment for the Following Curricula** | Materials Science: Specialisation Modeling: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory<br>Mechatronics: Technical Complementary Course: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Product Development, Materials and Production: Core Qualification: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>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** | • kinematics of undeformed and deformed bodies<br>• balance equations (balance of mass, balance of energy, ...)<br>• stress states<br>• material modelling |
| **Literature** | R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker<br><br>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** | • kinematics of undeformed and deformed bodies<br>• balance equations (balance of mass, balance of energy, ...)<br>• stress states<br>• material modelling |
| **Literature** | R. Greve: Kontinuumsmechanik: Ein Grundkurs für Ingenieure und Physiker<br><br>I-S. Liu: Continuum Mechanics, Springer |

## 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** | Dr. Erica Lilleodden |
| **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<br>- assess their own strengths and weaknesses<br>- assess their own state of learning in specific terms and to define further work steps on this basis guided by teachers.<br>- 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** | 90 min |
| **Assignment for the Following Curricula** | Materials Science: Core Qualification: Compulsory<br>Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Production: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Materials: Compulsory<br>Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: 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**<br>Of a perfect crystalline material, theoretical critical shear stress<br><br>**Real strength of brittle materials**<br>Energy release reate, stress intensity factor, fracture criterion<br><br>**Scattering of strength of brittle materials**<br>Defect distribution, strength distribution, Weibull distribution<br><br>**Heterogeneous materials I**<br>Internal stresses, micro cracks, weight function,<br><br>**Heterogeneous materials II**<br>Toughening mechanisms: crack bridging, fibres<br><br>**Heterogeneous materials III**<br>Toughening mechanisms. Process zone<br><br>**Testing methods to determine the fracture toughness of brittle materials**<br><br>**R-curve, stable/unstable crack growth, fractography**<br><br>**Thermal shock**<br><br>**Subcritical crack growth)**<br>v-K-curve, life time prediction<br><br>**Kriechen**<br><br>**Mechanical properties of biological materials**<br><br>**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<br><br>D.J. Green, An introduction to the mechanical properties of ceramics", Cambridge University Press, 1998<br><br>B.R. Lawn, Fracture of Brittle Solids", Cambridge University Press, 1993<br><br>D. Munz, T. Fett, Ceramics, Springer, 2001<br><br>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** | Dr. Erica Lilleodden |
| **Language** | DE/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.<br><br>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<br><br>Aktuelle Publikationen<br><br>Bücher:<br><br>Introduction to Dislocations, by D. Hull and D.J. Bacon<br><br>Theory of Dislocations, by J.P.  Hirth and J. Lothe<br><br>Physical Metallurgy, by Peter Hassen |

## 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.<br>They can explain the complex structure-property relationship and<br>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: Specialisation Engineering Materials: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Production: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Materials: Elective Compulsory |

### Course L1895: Processing of fibre-polymer-composites

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|---|---|
| **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).<br>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.<br>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").<br>After the test during the "customer / supplier conversation" there is a mutual feedback-talk ("lessons learned") in order to ensure the continuous improvement. |
| **Literature** | Customer Request ("Handout") |

## Module M1151: Material Modeling

**Courses**

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

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|---|---|
| **Module Responsible** | Prof. Christian Cyron |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of linear and nonlinear continuum mechanics as taught, e.g., in the modules Mechanics II and Continuum Mechanics (forces and moments, stress, linear and nonlinear strain, free-body principle, linear and nonlinear constitutive laws, strain energy) |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can explain the fundamentals of multidimensional consitutive material laws |
| *Skills* | The students can implement their own material laws in finite element codes. In particular, the students can apply their knowledge to various problems of material science and evaluate the corresponding material models. |
| **Personal Competence** | |
| *Social Competence* | The students are able to develop solutions, to present them to specialists 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 materials modeling 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** | 45 min |
| **Assignment for the Following Curricula** | Materials Science: Specialisation Modeling: Elective Compulsory<br>Mechanical Engineering and Management: Specialisation Materials: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Elective Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Product Development, Materials and Production: Core Qualification: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory |

### Course L1535: Material Modeling

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|---|---|
| **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<br><br>- anisotropy (material behavior depending on direction, e.g., in fiber-reinforced materials)<br>- plasticity (permanent deformation due to one-time overload, e.g., in metal forming)<br>- viscoelasticity (absorption of energy, e.g., in dampers)<br>- creep (slow deformation under permanent load, e.g., in pipes)<br><br>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** | |

| 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):<br>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.<br>• 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.<br>• 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:<br>• To select, apply and, if necessary, develop further methods that are suitable for solving the specialized problem in question.<br>• 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.<br>• To develop new scientific findings in their subject area and subject them to a critical assessment. |
| **Personal Competence** | |
| *Social Competence* | Students can<br>• Both in writing and orally outline a scientific issue for an expert audience accurately, understandably and in a structured way.<br>• 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:<br>• To structure a project of their own in work packages and to work them off accordingly.<br>• To work their way in depth into a largely unknown subject and to access the information required for them to do so.<br>• 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<br>Bioprocess Engineering: Thesis: Compulsory<br>Chemical and Bioprocess Engineering: Thesis: Compulsory<br>Computer Science: Thesis: Compulsory<br>Electrical Engineering: Thesis: Compulsory<br>Energy and Environmental Engineering: Thesis: Compulsory<br>Energy Systems: Thesis: Compulsory<br>Environmental Engineering: Thesis: Compulsory<br>Aircraft Systems Engineering: Thesis: Compulsory<br>Global Innovation Management: Thesis: Compulsory<br>Computational Science and Engineering: Thesis: Compulsory<br>Information and Communication Systems: Thesis: Compulsory<br>International Management and Engineering: Thesis: Compulsory<br>Joint European Master in Environmental Studies - Cities and Sustainability: Thesis: Compulsory<br>Logistics, Infrastructure and Mobility: Thesis: Compulsory<br>Materials Science: Thesis: Compulsory<br>Mathematical Modelling in Engineering: Theory, Numerics, Applications: Thesis: Compulsory<br>Mechanical Engineering and Management: Thesis: Compulsory |

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