TUHH
Hamburg
University of
Technology

# Module Manual

Master of Science (M.Sc.)

# International Management and Engineering

Cohort: Winter Term 2019

Updated: 27th January 2023

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# Program description

## Content

It is the major objective of the Masters degree programme „International Management and Engineering“ to offer students the opportunity to acquire the competencies which they will need for their future career, e.g. in a technical or management department of companies in different branches of industry, or for a future career in research (i.e. a PhD) in the area of Management and Engineering. The students’ future sphere of activities hence may include research and development, leadership and management of international projects or tasks in operational or strategic management.

In particular, after having finished their studies, students are supposed to be able to carry out managerial functions in international companies and to act successfully at the interface of management and technology. They can successfully apply methods for solving managerial as well as technical problems, and they are also able to solve new problems in changing and volatile situations. Moreover, they will develop a critical attitude towards these methods and are also able to advance the methods, whenever necessary. Hence, they have a sound foundation for acting responsibly in their jobs and for taking ethical aspects and consequences of their decisions in account.

## Career prospects

Graduates of the„International Management and Engineering“ programme find many job opportunities in industry, in particular in international companies, in service companies, in particular in consulting, and in research and development. They are particularly qualified for responsible and leading positions at the interface of management and technology.

## Learning target

The graduates have acquired the basic skills, specialized knowledge and additional competences required for a national and/or international career in the interdisciplinary field of industrial engineering. They have gained scientifically based specialized knowledge of business sciences, as well as an in-depth knowledge of engineering disciplines. Hence, they are qualified for performing interdisciplinary tasks, and they are able to pursue stand-alone tasks at the interface of business management and technology. Moreover, the graduates have the capability to work in strategic and operational management functions in different types of enterprises, including multinationals, or to pursue an academic career, i.e. a PhD.

In particular, the graduates are able to apply the methods and techniques required to solve both business-related and technological tasks, to critically analyze these methods, and to improve their development by applying new insights.

Furthermore, the graduates have acquired competences that enable them:

- To transfer their theoretical knowledge into practice

- To take on complex planning tasks in global value-added networks and successfully apply their theoretical knowledge of the management and engineering sciences in practice.

- To participate, in a leading function, in international technology and management-oriented projects.

- To analyze and critically assess processes, systems, and innovative technologies in different business-related areas.

- To also systematically consider the non-technical consequences of engineering activities and incorporate these responsibly and ethically in a socio-economic context.

- To independently acquire relevant knowledge from the scientific literature, to judge relevant publications critically and to write scientific reports.

- To carry out their own research projects

- To successfully communicate with experts from their field and from other fields in German and English

Moreover, the key qualifications acquired in the Bachelor’s program were extended and enhanced by means of suitable teaching methods within the Master’s degree course. In addition, the students’ intercultural competence was developed and their ability to work in a team was improved.

## Program structure

In this degree programme, students gain broad management competencies, especially for the application in an industrial and international operational area. Students can enhance their knowledge in special fields as, e.g. Supply Chain Management, Technology Management, Human Resource Management, Strategic Management or Marketing, Controlling or Operations Research. They can concentrate on different core areas, namely on

- Marketing and Technology

- Supply Chain Management and Logistics

- Corporate Management

- Entrepreneurship

In addition, students can select an engineering specialization. There are different areas of engineering on offer:

- Civil Engineering

- Electrical Engineering

- Power and Environmental Engineering

- Information Technology

- Logistics

- Aviation Systems

- Mechatronics

- Product Development and Production

- Renewable Energy

- Process Engineering and Biotechnology

As the third semester does not contain any comp1ulsory courses, it is particularly well suited for a stay abroad at one of the many partner universities of TUHH. The TUHH strongly supports students when they are planning such a stay abroad.

# Core Qualification

## Module M0560: Institutional Environment of International Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Research Methods in International Management (L1911) | Lecture | 1 | 2 |
| Business Environment of Selected Countries (L0159) | Seminar | 3 | 4 |

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|---|---|
| **Module Responsible** | Prof. Thomas Wrona |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge in international and intercultural management, familiarity with the content of the International Management lecture |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Knowledge: Students will be able to<br>• evaluate the importance of the institutional framework for doing business in different countries<br>• outline and critically reflect the economic and legal framework in selected countries<br>• understand historic, demographic and economic indicators in specific economic areas within an international context<br>• understand and apply methods of analysis of the external environment (competitive analysis , industry structure analysis by Porter, PESTEL analysis, Porter's Diamond and Cluster analysis)<br>• explain different objectives of empirical research in general and in international management research in particular<br>• explain and critically reflect on different ways of organizing empirical research<br>• describe and distinguish ideal-typical research designs |
| *Skills* | Skills: based on the acquired knowledge, Students will be able to<br>•<br>• recognize and subsequently assess different risks and other influencing factors while conducting an environmental analysis in an international context<br>• identify typical problems within international management to develop solution proposals<br>• analyze, interpret and present external and internal information in different, international economic contexts<br>• to set up a suitable research design based on specific problems within international management<br>• to assess the influence of different research goals on the selected research design<br>• to conceptualize an ideal research process for a simple research problem<br>• to adequately integrate theoretical knowledge in international management into a research design (qual./quan.)<br>• to critically evaluate the quality and meaningfulness (rigor / relevance) of exemplary empirical studies |
| **Personal Competence** | |
| *Social Competence* | Social competence: After completion of the module Students will be able to<br>• conduct subject-specific and interdisciplinary discussions<br>• present results of their work<br>• respectful work in a team |
| *Autonomy* | Self-employment: After completion of the module Students will bee able to<br>• work independently and to transfer the acquired knowledge to new problem areas |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes · **Bonus** 33 % · **Form** Midterm · **Description** |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | approx. 30 pages and presentation |
| **Assignment for the Following Curricula** | International Management and Engineering: Core Qualification: Compulsory |

| Course L1911: Research Methods in International Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Thomas Wrona |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Foundation of empirical research<br>• Types of scientific statements<br>• Objectives of empirical research (designs)<br>• Special research questions of international management research<br>• Content and process of quantitative international management research<br>• Content and process of qualitative international management research<br>• General issues of empirical research (indication of research designs, quality criteria)<br>• Literature reviews as examples of non-empirical research |
| **Literature** | • Bortz, J./Döring, N. (2006): Forschungsmethoden und Evaluation für Human- und Sozialwissenschaftler, 4. überarb. Aufl., Nachdruck, Heidelberg 2009.<br>• Brühl, R. (2014): Wie Wissenschaft Wissen schafft - Wissenschaftstheorie für Sozial- und Wirtschaftswissenschaften, Stuttgart 2014 (UTB Taschenbuch)<br>• Bryman, A./Bell, E. (2015). Business research methods. Oxford University Press, USA.<br>• Eisenhardt, K. M./Graebner, M. E. (2007): Theory building from cases: Opportunities and challenges, in: Academy of Management Journal, 50. Jg. 2007, Heft 1, S. 25-32.<br>• Flick, U. (2009). An Introduction to Qualitative Research (4th ed.). Thousand Oaks, CA: Sage Publications.<br>• Kirsch, W./Seidl, D./van Aaken, D. (2007): Betriebswirtschaftliche Forschung. Wissenschaftstheoretische Grundlagen und Anwendungsorientierung, Stuttgart 2007.<br>• Oesterle, Michael-Jörg, and Stefan Schmid. "Internationales Management." Forschung, Lehre, Praxis. Schäffer-Poeschel, Stuttgart (2009).<br>• Töpfer, A. (2009): Erfolgreich forschen, Berlin/Heidelberg 2009.<br>• Wrona, T. (2005): Die Fallstudienanalyse als wissenschaftliche Forschungsmethode, ESCP-EAP Working Paper Nr. 10, Berlin 2005 (wird zum Download zur Verfügung gestellt).<br>• Wrona, T./Bauer, A. (i.V.): Theory-based Qualitative Case Study Research (Lehrbuch in Vorbereitung)<br><br>Übungstexte, die während der Vorlesung herausgegeben werden. |

| Course L0159: Business Environment of Selected Countries | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Thomas Wrona |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Competitiveness of firms/industries/nations/regions<br>• Competition Across Locations & Global Strategy for MNCs<br>• Industry Competition, Strategy and Location<br>• The Diamond Model: developing/developed Economies<br>• Clusters and Cluster Development<br>• Harvard case studies of selected firms/industries/nations/regions<br>• Development and presentation of case studies in groups<br>• Participant-centered learning<br>• Composition of a cluster- and country-related seminar thesis |
| **Literature** | • Audretsch, D. and Feldman, M. (1996), “Knowledge spillovers and the geography of innovation and production”, American Economic Review, Vol. 86 No. 3, pp. 630-640.<br>• Bamberger, I. and Wrona, T. (2012), Strategische Unternehmensführung, 2., erweiterte Auflage, München 2012.<br>• Bamberger, I./Wrona, T. (2012): Strategische Unternehmensführung, 2., erweiterte Auflage, München 2012.<br>• Bell, G.G. (2005), “Clusters, networks, and firm innovativeness”, Strategic Management Journal, Vol. 26 No. 3, pp. 287-295.<br>• Krugman, P. (1991), Geography and Trade, MIT Press, Cambridge, MA.<br>• Porter, M.E. (1990), The Competitive Advantage of Nations, Free Press, New York, NY.<br>• Porter, M.E. (1991): Nationale Wettbewerbsvorteile, München 1991<br>• Porter, M.E. (2008): On Competition, Boston MA 2008<br>• Tallman, S., Jenkins, M., Henry, N. and Pinch, S. (2004), “Knowledge, clusters and competitive advantage”, Academy of Management Review, Vol. 29 No. 2, pp. 258-271. |

## Module M0698: Accounting

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Management and Financial Accounting (L0143) | Lecture | 4 | 4 |
| Corporate Finance (L0107) | Lecture | 2 | 2 |

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| **Module Responsible** | Prof. Matthias Meyer |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge of accounting and general business administration.<br><br>The previous knowledge required for successful completion of this module, in particular of bookkeeping, is imparted within the framework of an e-learning programme.<br><br>Through an online test, the student can earn points which are added to the final examination result of the module.<br><br>Students receive access and further information to the corresponding online learning module upon enrolment. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students know ...<br><br>• the basic structure of the current cost recording and allocation and can be used in<br>• Different cost classifications (variable/fixed, individual/joint) and can classify them theoretically;<br><br>• Subdivide into cost element, cost center and cost object accounting<br>• the concept and necessity of cost centers;<br>• Different costing procedures<br>• simulation-based methods for the design of cost accounting systems<br>• Instruments for cost planning and control;<br>• various partial cost accounting systems as an alternative to full cost accounting and can characterize these comprehensively;<br>• modern developments in cost management;<br>• the Accuracy Effort Tradeoff and variance-based criticisms of Activity-Based Costing<br>• the structure of the balance sheet, and they can explain individual balance sheet items with regard to their approach and valuation<br>• the components of the financial statements according to HGB and IFRS and can explain them;<br>• the difference between the total cost method and the cost of sales method;<br>• Function and methodology of the audit;<br>• the procedure of balance sheet analysis and can explain the steps of method selection, data preparation and data evaluation<br>• the most important financial and performance indicators and can derive them<br>• The role of the finance function in internationally operating companies and the interdependencies between investment and financing<br>• the main theories and models in the field of investment and financing;<br>• Methods for evaluating companies and investment decisions;<br>• Approaches to risk assessment in the field of investment and financing and portfolio theory;<br>• alternative financing options and their specific design and valuation;<br>• the contents and methods of short- and long-term financial planning; |
| *Skills* | The students are able...<br><br>• to explain characteristics of the cost and activity accounting and to apply methods from this range to economical problem definitions<br><br>• to describe the tasks of cost type, cost centre and cost unit accounting as well as to discuss the classification into the basic schema of cost recording and allocation;<br>to differentiate between different possibilities of the case-by-case special allocation of cost center services and to implement them purposefully;<br>to characterize and apply different calculation methods depending on the homogeneity or heterogeneity of the created activity units;<br>to classify and apply marginal cost accounting as well as contribution margins related to bottlenecks as decision-oriented cost accounting systems and to interpret the results of their analyses;<br>to distinguish cost planning from cost management;<br>To apply process cost accounting and target costing and to interpret the results of their analyses;<br>interpret current research results on the design of cost accounting systems<br>to explain the connections between the different parts of the operational accountancy and to differentiate their addressees and arithmetic variables;<br>to explain and interpret the legal provisions of the German Commercial Code on accounting and bookkeeping and to apply them to common facts of business operations;<br>to identify and critically evaluate differences between HGB and IFRS with respect to material balance sheet items;<br>to explain the technique of balance sheet analysis, to apply it to the annual financial statements of various international companies (including IFRS) and to draw conclusions about the prevailing economic conditions there;<br>to explain theories and models for the investment management of international enterprises, to evaluate their application |

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| | possibilities and to reflect critically on the results;<br>to apply methods of financial mathematics to investment and financing problems and to use suitable software tools for the calculations;<br>to adequately evaluate investment projects of internationally operating companies using suitable business management methods and indicators, to determine the optimal investment portfolio and to decide on it;<br>to determine the capital requirements and capital costs of globally operating companies;<br>to evaluate financing alternatives and select them based on the results;<br>to determine, in the context of globalized financial markets, an appropriate level of dividends and the dividend policy of companies, as well as the type, volume, maturity and yield of corporate bonds;<br>to financially assess the attractiveness of acquisitions by international competitors. |
| **Personal Competence** | |
| *Social Competence* | The students can…<br>• analyse business problems in a team and develop solutions together;<br>present the results of their analyses in an understandable way, also in English;<br>explain the implications of current research results to others and to reflect critically on them togethe<br>• act as a competent contact within the framework of an audit;<br>• determine the ethical dilemmas of investment and financing decisions and to take them into account within the framework of decision analyses;<br>• assume leadership responsibility in questions of investment and financing in the company, but also in teamwork, and to present technically sound proposals for solutions. |
| *Autonomy* | The students are able…<br>• to apply the presented methods of cost accounting in order to analyze business problems and to interpret and critically evaluate the results;<br>to critically analyze the capital structure of globally operating companies<br>to transfer the theoretical knowledge about accounting into operational practice;<br>to decide independently which accounting methods can be used for which problems;<br>to acquire knowledge about the subject area independently and to transfer the acquired knowledge to new questions;<br>to use cost accounting systems independently and to design them purposefully;<br>to carry out operational accounting tasks independently, also in internationally active companies;<br>to use methods of the illustration and analysis of the seized business transactions, in order to analyze economical problem definitions and to evaluate the results critically;<br>to interpret and critically evaluate the key figures determined within the framework of a balance sheet analysis;<br>to strategically optimize the capital structure of a company and to use the different forms of corporate financing on the global financial markets in an appropriate manner;<br>to carry out short-term and long-term financial planning;<br>to analyse and optimise the profit and risk position of an internationally operating company;<br>to evaluate companies and make international acquisition decisions. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>Yes / 33 % / Midterm /<br>Yes / 5 % / Excercises / |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | International Management and Engineering: Core Qualification: Compulsory |

| Course L0143: Management and Financial Accounting | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 4 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 64, Study Time in Lecture 56 |
| **Lecturer** | Prof. Matthias Meyer |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | **Management Accounting**<br><br>• Cost type accounting: Cost concepts, recognition and evaluation of resources<br>• Cost center accounting: Expense distribution, stepladder method, equation method, indirect cost apportionment, special settlement of cost center service<br>• Costing: Causer-pays and marginal principle, output costing, equivalence number costing, overhead calculation, charge rate calculation<br>• Cost unit accounting: unit-of-output costing, cost unit period costing, total cost accounting, cost of sales accounting<br>• Standard cost accounting: Cost resolution, fixed and flexible planned cost calculation, marginal costing<br>• Breakeven analysis: Direct costing, multi-level fixed cost absorption, bottleneck-related contribution margin in operational production program planning<br>• Modern cost management: Relevance Lost, activity based costing, target costing<br><br>**Financial Accounting**<br><br>• Importance of financial accounting and initial overview<br>• Accounting principles and regulations: General approach, valuation and disclosure regulations (HGB)<br>• Total and sales cost format, annex<br>• International financial reporting (IFRS, US-GAAP)<br>• Accounting policy<br>• Auditing<br>• Balance sheet analysis: Choice of method(s), data processing, data evaluation<br>• Annual report analysis (financial: investment analysis, financing analysis, liquidity analysis; performance: cost analysis, earnings analysis, profitability analysis)<br><br>**Exercise:**<br><br>Both parts of the lecture include an exercise. For the Managment Accounting part there are also Web-based exercises for self-testing. |
| **Literature** | **Literatur internes Rechnungswesen:**<br><br>1. Skript und Unterlagen, die zur Vorlesung und Übung herausgegeben werden.<br>2. Ausgewählte Bücher:<br>◦ Horngren, C. T. /Bhimani, A./Datar, S. M./Foster, G. (2005): Management and Cost Accounting, 3rd ed., Harlow.<br><br>• Friedl, G./ Hofmann, C./Pedell, Burkhard. (2010): Kostenrechnung: eine entscheidungsorientierte Einführung, München.<br><br>• Joos-Sachse, T. (2006): Controlling, Kostenrechnung und Kostenmanagement, 4. Aufl., Stuttgart.<br>• Schweitzer, M./Küpper, H.-U. (2008): Systeme der Kosten- und Erlösrechnung, 9. Aufl., München.<br>• Weber, J./Weißenberger, B. (2010): Einführung in das Rechnungswesen, 8. Aufl., Stuttgart.<br><br>**Literatur externes Rechnungswesen:**<br><br>1. Skript und Unterlagen, die zur Vorlesung und Übung herausgegeben werden.<br>2. Ausgewählte Bücher:<br>◦ Coenenberg, A./Haller, A./Mattner, G./Schultze, W. (2009): Einführung in das Rechnungswesen, 3. Aufl., Stuttgart.<br><br>• Döring,U./Buchholz, R. (2009): Buchhaltung und Jahresabschluss, 11. Aufl., Berlin.<br>• Heinhold, M. (2010): Buchführung in Fallbeispielen, 11. Aufl., Stuttgart.<br><br>• Pellens, B./Fülbier, R. U./Gassen, J./Sellhorn, T. (2011): Internationale Rechnungslegung: IFRS 1 bis 9, IAS 1 bis 41, IFRIC-Interpretationen, Standardentwürfe Mit Beispielen, Aufgaben und Fallstudie 8. Aufl., Stuttgart.<br><br>• Wöhe, G./Döring, U. (2010): Einführung in die allgemeine Betriebswirtschaftslehre, 24. Aufl., München.<br><br>1. Gesetzestexte/Standards:<br><br>• Handelsgesetzbuch (HGB) (Achtung: BilMoG!), teilw. Aktiengesetz (AktG)<br><br>http://www.gesetze-im-internet.de/hgb/index.html |

| Course L0107: Corporate Finance | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **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. |

## Module M0524: Non-technical Courses for Master

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|---|---|
| **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. |

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| **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 |

| **Course L1775: “What’s up, Doc?” Science and Stereotypes in Literature and Film** | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Dr. Jennifer Henke |
| **Language** | EN |
| **Cycle** | WiSe/SoSe |
| **Content** | Popular novels and films significantly contribute to the public understanding of science and its representatives. How to define “good” or “bad” science is negotiated in a variety of artistic works. Stereotypes such as the “mad scientist”, which originated in early nineteenth century England, continue to persist. Mary Shelley created the prototype of the obsessive and reckless scientist in Frankenstein - The Modern Prometheus (1818) who conducts his forbidden experiments in a secret lab and crosses ethical boundaries. This masculine stereotype has been followed by further ones such as the noble, adventurous or clumsy scientist, whereas scholars have only recently begun to consider the representation of female science.<br><br>First, this seminar is devoted to selected formations of knowledge in relation to literature from classical antiquity to the present. Second, the focus shall rest on the production of persistent stereotypes in various media formats such as novels or films while paying particular attention to the aspect of gender. The overall goal of the seminar is an understanding of science as a cultural practice.<br><br>Requirements for participation: Shelley, Mary: Frankenstein. New York: Norton, 2012. Please pay attention to the exact publication dates. |
| **Literature** | Teilnahmevoraussetzungen: Shelley, Mary: Frankenstein. New York: Norton, 2012. Bitte ausschließlich diese Edition anschaffen. |

| Course L2064: 120 years of film history | |
|---|---|
| **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 min |
| **Lecturer** | Prof. Margarete Jarchow |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The lecture deals with the relationship between the develpoment of film technology, film aesthetics, and society. Based on the nineteenth-century film's precursors such as the laterna magica, photography and kinetoscope, crucial stages of more than 120 years of film history are studied chronologically in terms of: How does the development of new media techniques reflect certain social changes and needs? What new forms of aesthetic expression are possible through such technical innovations as the introduction of sound film, color film or handheld camera? And to what extent do these new forms of aesthetic expression in turn reflect certain social sensitivities, ultimately the respective zeitgeist? Main topics of the lecture are: the technical euphoria of the 19th century, the early film, the German Expressionist film, the classic Hollywood cinema, the European postwar cinema, exploitation and underground cinema, New Hollywood, the blockbuster cinema, independent cinema up to current phenomena like the „cinema of dissolution“. On the one hand, the participants learn in-depth, detailed knowledge of the history, meaning and analysis of the medium film and thereby acquire media literacy. On the other hand, the participants should gain a deeper understanding of the real interdependencies of technologies in culture and society and their historical transformation processes through an interdisciplinary perspective on film (history of technology, media studies and social science). |
| **Literature** | |

| Course L1774: Applied Arts: Form and Function | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Prof. Margarete Jarchow, Dr. Christian Lechelt |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | From Arts & Crafts to modern Design - applied arts focus on the design of all kinds of products. Therefore applied arts allow to come to more thorough conclusions about social, historical, cultural issues.<br><br>In the course the impact of social developments on these particular genres are discussed. |
| **Literature** | Wird noch angegeben<br><br>Will be announced in lecture |

| Course L2338: Bauhaus architecture - a search for traces | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Dr. Jörg Schilling |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | The „100 years of bauhaus“ centenery also involved examining the references, differences and similarities to Hamburg architecture from 1919-1933.<br>The seminar intends to find these traces in social (i.e. Jarrestadt) and private (i.e. Landhaus Michaelsen / Puppenmuseum) housing as well as in numerous other building projects. During the excursions to buildings by Hamburg architects like Fritz Schumacher, Gustav Oelsner, Karl Schneider and others we will discuss aspects related to architectural modernism. |
| **Literature** | wird im Seminar bekanntgegeben |

| Course L1882: Facilitating groups in problem-oriented courses | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Fachtheoretisch-fachpraktische Arbeit |
| **Examination duration and scale** | Schriftliche Ausarbeitung (in mehreren Teilen) sowie eine Präsentation, Teilnahme an Gruppendiskussionen |
| **Lecturer** | Siska Simon |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | Content:<br>- Changing the role of the teacher in problem-oriented courses<br>- Structure and benefits of problem-oriented courses<br>- Attitude and beliefs concerning teaching and learning<br>- Question and discussion techniques<br>- Group dynamic processes<br>- Situation-related interventions<br>- dealing with heterogeneous groups<br>- Moderation and presentation<br>- Interference levels and conflict management<br>- Feedback processes and methods<br><br>Methods:<br>- impulse lectures and group work<br>- Planning, execution and reflection of an exemplary course unit<br>- Micro teaching and feedback<br>- peer observation and feedback |
| **Literature** | Auszüge aus Fachliteratur zu oben genannten Themen werden in der Veranstaltung ausgegeben |

| Course L1990: Clash of Cultures. Film and TV series as images of the own and the other | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Jacobus Bracker |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | Images are negotiating concepts of the own, other and alien. Especially tv series like “Game of Thrones”, “Vikings”, or “The Walking Dead” and films like “Alien” or “Lord of the Rings” show clashes of cultures. Irrespective of their genre - fantasy, science fiction, or history - the moving images use always similar patterns to show and tell the own and the other. During the seminar we will deal with such concepts and concepts of culture and the specifics of film and series to watch and analyse selected examples from these perspectives. |
| **Literature** | Literaturhinweise, Texte etc. werden zu gegebener Zeit online zur Verfügung gestellt. |

| Course L1176: The end is near - Survival in the post-apocalypse | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Dr. Marlis Bussacker |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | According to the FAZ in December 2015, the end of the world is booming. At all times, people have dealt with the imminent future scenario of ultimate horror - the collapse of their own world. Where does the idea of a final disaster come from? What's so fascinating about our own demise? During the seminar we will take a look at European cultural history, which is closely linked to mythological and religious prophecies about the end of the world.<br><br>However, this question, or rather the question of survival in a post-apocalyptic world, has fortunately remained speculative to this day despite regular predictions. Since the end of the world has not yet happened in reality, we are therefore dependent on the imagination of writers, screenwriters and directors who have anticipated the event in an infinite number of texts, films and series.<br><br>Based on selected films and texts, the seminar will focus on the questions of which apocalyptic scenarios are developed, with which problems the survivors are confronted and how they deal with the situation and with each other. The focus is on the reactions of people in a state of extreme threat. Which survival strategies are presented to us, how do we assess the behaviour of the actors, can we create alternatives?<br><br>Furthermore, the effect of the genre on the recipient will be discussed. Do we dismiss films like Armaggedon and The Day After Tomorrow as entertaining thrills? Do we just enjoy the special effects? Do we feel threatened? Do we take them in the end as real instructions for action? Do they make us reflect? Or are even current social discourses reflected in the garment of the apocalypse? |
| **Literature** | |

| Course L1441: German as a Foreign Language for International Master Programs | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 4 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 64, Study Time in Lecture 56 |
| **Examination Form** | Klausur |
| **Examination duration and scale** | |
| **Lecturer** | Dagmar Richter |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | Master’s German course in cooperation with IBH e.V. - Master’s German courses at different levels<br><br>In the international studies program these are obligatory for non-native speakers of German and for students without a DSH certificate or equivalent TEST-DAF result. Grading after an aptitude test. All other students must sign up for a total of 4 ECTS from the catalog of non-technical supplementary courses. |
| **Literature** | - Will be announced in lectures - |

| Course L1884: The Hamburger Speicherstadt - from achievements of engineering to world cultural heritage | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | 20 minütiges Referat mit anschließender Diskussion |
| **Lecturer** | Dr. Jörg Schilling |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | The seminar wants to show the problems and challenges for the engineers, who built the Hamburger Speicherstadt and their sustainable architectural solutions, which are still of vital importance and the basis for becoming a world cultural heritage. |
| **Literature** | u.a.: Hamburg und seine Bauten unter Berücksichtigung seiner Nachbarstädte Altona und Wandsbek, hg. vom Architekten- und Ingenieur-Verein zu Hamburg, Hamburg 1890; Karin Maak: Die Speicherstadt im Hamburger Hafen, Hamburg 1895; Hermann Hipp: Freie und Hansestadt Hamburg, Köln 1989; Matthias von Popowski: Franz Andreas Meyer (1837-1901). Oberingenieur und Leiter des Ingenieurwesens von 1872-1901, in: Wie das Kunstwerk Hamburg entstand, hg. v. Dieter Schädel, Hamburg 2006, S. 64-79; Ralf Lange: HafenCity + Speicherstadt : das maritime Quartier in Hamburg, Hamburg 2010. |

| Course L1996: Digital culture(s): from subculture to media mainstream | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Dr. Oliver Schmidt |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | The course gives an introduction to the development of digitization in a media cultural perspective. In addition to technical aspects, we will focus on the cultural impact of digitization for current media users and the ermergence und development of media subcultures from the late 1970s to the 21st century. On the one hand, we will deal with questions such as: What is digitization? What is culture? What are digital (sub)cultures? In this context, the concept of ‚digital natives‘ and ‚digital immigrants‘, coined by Marc Prensky, will also be discussed. On the other hand, there will be a historical perspective on topics and developments such as the mediatization oft he children’s room in the early 1980s, the hacker scene, video game culture, the demo scene, digital culture in cinema, 8-bit culture, digital aesthetics , net art, post-digitality and ultimately the question of how digital subcultures have become part of the media mainstream at the beginning of the 21st century. |
| **Literature** | |

| Course L2367: Digital art | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | Referat ca. 20 min. plus anschließende Diskussion |
| **Lecturer** | Dr. Imke Hofmeister |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | Digitalization is having a major impact on many areas of our lives and the use of digital technologies in art and design has increased rapidly. After all, art is not only subject to constant change, but also constantly adapts to technical conditions. After the photographic art of the mid-19th century and the video art of the 1960s, which already brought about major changes in artistic creation, digital art is becoming increasingly important in the field of media art. The first attempts to use the computer with corresponding graphic software as an artistic medium took place in the 80/90s of the 20th century. Since then, there has been a broad development in the field of digital art, which now encompasses the most diverse digital pictorial phenomena and art genres and is thus intertwined in its objects, theories and practices with digital media in a variety of ways. The seminar gives an overview of the history of digital art and its different genres. These include, for example, photopaintings, where digital manipulation, filtering processes and painting can process the image and transform it over many stages into a completely new form. Also 3-D images, vector graphics, mathematical art and computer art in general. At the same time, the digital development in art is to be illuminated, from the first beginnings on the computer with comparatively simple "digital aids", e.g. in the form of simple image processing programs, to the present sophisticated graphic tools.<br><br>In addition, the presentation, dissemination and conservation possibilities of digital art will also be discussed, which can be disseminated very well on the Internet primarily because it can be displayed on a computer screen. The great fascination with digital creative work and the almost inexhaustible possibilities offered by the medium of computers to artists, who will continue to ensure that digital art finds a permanent place alongside traditional media, will also be discussed. Finally, in contrast to the traditional production methods in the field of fine arts and design, there are always new manifestations of digital art, which ultimately give not only the "trained" artist but also the layman far-reaching possibilities for artistic expression. And all this in the spirit of the performance artist Joseph Beuys , who postulated, every human being is capable of creativity, indeed "every human being is an artist".<br><br>The seminar will also discuss the question of how digital art can be described as "the" contemporary art, i.e. contemporary art in the age of digital technology. Furthermore, it is of great interest to what extent the perception of art per se has already changed and will continue to change in a digitalized society. |
| **Literature** | folgt |

| Course L1725: Introduction to the Science & Technoloy Studies (STS) | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | Gruppenreferat (30 bis 45 Minuten, Eigenanteil je Person 10 bis 15 Minuten) inkl. schriftlicher Ausarbeitung, Ggf. alternativ eine längere, schriftliche Ausarbeitung. |
| **Lecturer** | Dr. Simon Egbert |
| **Language** | EN |
| **Cycle** | WiSe/SoSe |
| **Content** | Since the end of the 1980's or the beginning of the 1990's, in the Sociology of Technology a line of research has emerged which initially called for a socialization of the sociology of technology (especially through the Social Construction of Technology Approach [SCOT]) and right away called for its re-materialisation (especially through Bruno Latour and the Actor-Network Theory). Technologies, thus their basic idea, are always intertwined with society and shaped by their socio-cultural context. In reverse, society is also inherently formed by the existing technologies and an adequate sociology of technology has to deal especially with the interaction of both. In the seminar at hand first of all an overview shall be given about the classical sociology of technology which routinely used argumentations inspired by technological determinism, which shall be followed by the presentation of the SCOT-approach. The later in turn was criticised by the Actor-Network Theory (which will be presented in a separate section as well) as being social deterministic which has led to a rather heated debate about the agency of technological artefacts, which shall be presented and discussed in a further part of the seminar. In the last section of the class it shall be determined what kind of relevance the sociological analysis of technological artefacts and their societal embedding can or could implicate for the own lifeworld of the students - especially of course with special focus on their engineer studies. |
| **Literature** | Bammé, Arno (2009): Science and Technology Studies: ein Überblick. Marburg: Metropolis.<br><br>Degele, Nina (2002): Einführung in die Techniksoziologie. München: Fink.<br><br>Hackett, Edward et al. (Hrsg.) (2008): The Handbook of Science and Technology Studies. 3$^{rd}$ Edition. Cambridge: MIT Press.<br><br>Häußling, Roger (2014): Techniksoziologie. Baden-Baden: Nomos.<br><br>MacKenzie, Donald/Judy, Wajcman (2003): The social shaping of technology. 2$^{nd}$ Edition. Maidenhead et al.: Open University Press.<br><br>Sismondo, Sergio (2010): An Introduction to Science and Technology Studies, 2$^{nd}$ Edition.<br><br>Chichester: Wiley-Blackwell. |

| Course L2336: Introduction to Marxian Theory of Economy | |
|---|---|
| **Typ** | Seminar |
| **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 min |
| **Lecturer** | Dr. Martin Schütz |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | Capitalism - what’s the definition in Marxian economical theorie? Which are the functions of gold, money, interest?<br>Focusing on the Marxian basis categories Ware - Gebrauchswert - Tauschwert - Wert - Arbeit - Austauschprozess - Geld - Zirkulation - Arbeitskraft, the subjects of the lecture are the first four chapters of ‘Das Kapital’ vol. 1, accompanied by discussion of neo-classical theory, monetarism etc. |
| **Literature** | Karl Marx, Das Kapital, Band 1, Berlin 1962ff (=Marx-Engels-Werke [MEW] Bd. 23), S. 1-390<br>Dieser Text steht text- und seitengenau im Internet zur Verfügung: http://www.mlwerke.de/me/me23/me23_000.htm oder http://www.zeno.org/Philosophie/M/Marx,+Karl/Das+Kapital<br>David Harvey, Marx‘ Kapital lesen, Hamburg 2017, Seiten 1-214<br>Begleitend: Harvey selbst hat seine ‚Kapital‘-Seminare (auf Englisch) als Stream veröffentlicht: http://davidharvey.org/reading-capital/<br>Ergänzende Literatur:<br><br>Altvater, Elmar (Hg.) (1999): Kapital.doc. Das Kapital (Bd. 1) von Marx in Schaubildern mit Kommentaren. Mit CD-ROM. Münster<br>Artus, Ingrid u.a. (Hg.) (2014): Marx für SozialwissenschaftlerInnen. Eine Einführung. Wiesbaden<br>Fülberth, Georg (2008): G Strich. Kleine Geschichte des Kapitalismus. 4., verb. und erw. Aufl. Köln<br>Krause, Alexandra (2014): Kritik der Politischen Ökonomie - Wachstum als Imperativ kapitalistischen Wirtschaftens. In: Artus (2014) S. 135-160.<br>Münch, Richard (2008): Soziologische Theorie. Grundlegung durch die Klassiker. Korr. Nachdr. 2008. Frankfurt/Main (Soziologische Theorie, 1).<br>Nachtwey, Oliver (2014): Arbeit, Lohnarbeit und Industriearbeit. In: Artus (2014) S. 109-134<br>Söllner, Fritz (2015): Die Geschichte des ökonomischen Denkens. 4. Aufl. Berlin |

| Course L1994: Facts, Facts, Facts - Understanding and Applying Techniques of Journalism - in German | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Prof. Margarete Jarchow, Matthias Kowalski |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | Regardless of whether it is via classic channels such as newspapers and magazines or radio and TV as well as via internet, social media or via communication in specialist circles: Today we encounter journalism in almost all forms of public and private communication. But what makes a story really important in this flood of content? How do we recognize relevance? How do we expose fake news? In this block seminar the principles of journalistic techniques are imparted by means of practical examples and editorial exercises. The participants also develop tools to detect and deactivate manipulation and fake news. Regular attendance and attendance at all block dates is required. |
| **Literature** | |

| Course L2370: Facts, Facts, Facts - Understanding and Applying Techniques of Journalism - in English | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Prof. Margarete Jarchow |
| **Language** | EN |
| **Cycle** | WiSe/SoSe |
| **Content** | Regardless of whether it is via classic channels such as newspapers and magazines or radio and TV as well as via internet, social media or via communication in specialist circles: Today we encounter journalism in almost all forms of public and private communication. But what makes a story really important in this flood of content? How do we recognize relevance? How do we expose fake news? In this block seminar the principles of journalistic techniques are imparted by means of practical examples and editorial exercises. The participants also develop tools to detect and deactivate manipulation and fake news. Regular attendance and attendance at all block dates is required. |
| **Literature** | folgt |

| Course L0970: Foreign Language Course | |
|---|---|
| **Typ** | Seminar |
| **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** | Dagmar Richter |
| **Language** | |
| **Cycle** | WiSe/SoSe |
| **Content** | In the Field of the Nontechnical Complementary Courses students are able to chose foreign language courses. Therefore the Hamburger Volkshochschule offers a special language programm on TUHH campus for TUHH Students. It includes courses in english, chinese, french, japanese, portuguese, russia, swedish, spanisch and german as a foreign language. All lectures impart common language knowledge, english courses although english for technical purposes. |
| **Literature** | Kursspezifische Literatur / selected bibliography depending on special lecture programm. |

| Course L0983: Management and Communication | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | 90-minütige interaktive Präsentation im Team inkl. Handout. |
| **Lecturer** | Wibke Derboven |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The seminar will present basic elements of personality-promoting work organisation, motivation theories, different management concepts, communication theories and approaches to conflict and knowledge management. These subjects are applied to specific practical examples. Participants are given the opportunity to reflect on their own communicative and social behaviour. |
| **Literature** | Große Boes, Stefanie; Kaseric, Tanja (2010): Trainer-Kit. Die wichtigsten Trainings-Theorien, ihre Anwendung im Seminar und Übungen für den Praxistransfer. 4. Aufl. Bonn: managerSeminare Verlags GmbH<br>Klutmann, Beate (2004): Führung: Theorie und Praxis. Hamburg: Windmühle<br>Laufer, Hartmut (2011): Grundlagen erfolgreicher Mitarbeiterführung. Führungspersönlichkeit, Führungsmethoden, Führungsinstrumente. 11. Auflage. Offenbach: GABAL<br>Neuberger, Oswald (2002): Führen und führen lassen. 6. überarb. und erw. Aufl. Stuttgart: Lucius und Lucius<br>Schulz von Thun, Friedemann; Ruppel, Johannes; Stratmann, Roswitha (2002): Miteinander reden: Kommunikationspsychologie für Führungskräfte. 4. Aufl. Reinbek bei Hamburg |

| Course L1883: Guest, barbarian or subject with equal rights? ‘The refugee’ in the history of ‘Western’ political ideas. | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | 5-10 Minuten Vortrag im Rahmen eines Gruppenreferats; anschließend Diskussion |
| **Lecturer** | Dr. Simone Beate Borgstede |
| **Language** | DE/EN |
| **Cycle** | WiSe/SoSe |
| **Content** | The seminar discusses concepts of ‘the refugee’ in the history of ‘Western’ political ideas over a period of about 2,750 years. We will try to understand these concepts as historically distinct. We will also analyze the powerful effect of related stereotypes and images. We will read and contextualize philosophical, sociological, juridical, literary and political texts. In the second part of the seminar we will use the patterns we found to understand actual discourses on flight and migration. One aim is also to recognize alternative representations in the articulations and practices of the refugees themselves. |
| **Literature** | Agamben, Giorgio, ‚Homo Sacer: Die souveräne Macht und das nackte Leben.’<br><br>Arendt, Hannah, ‚Wir Flüchtlinge’ und ‚Das Recht, Rechte zu haben’.<br><br>Aristoteles, Politik und Platon, Politeia (Auszüge).<br><br>Derrida, Jacques, ‚Weltbürger aller Länder, noch eine Anstrengung!’<br><br>Erpenbeck, Jenny: Gehen, ging, gegangen. Roman.<br><br>Genfer Konvention und Menschenrechtserklärung.<br><br>Homer, Die Odyssee.<br><br>Simmel, Georg, ‚Exkurs über den Fremden’.<br><br>Dazu kommen Textstellen aus Bibel und Koran, aktuelle Interviews mit Migrationsforscher_innen wie Manuela Bojadzijev und Vassilis Tsianos, aber auch Erklärungen von Geflüchteten-Gruppen, Musiktexte, Fotographien und Filmspots. |

| Course L1844: Stay cool in conflict. Nonviolent Communication by Marshall Rosenberg | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | 2-3 Seiten bzw. 10-20 Minuten plus anschließende Besprechung |
| **Lecturer** | Dr. Claudia Wunram |
| **Language** | EN |
| **Cycle** | WiSe/SoSe |
| **Content** | „Words can build bridges or create rafts“ - this is also true for the scientific and business world. For example, how do I react if I get attacked in a professional debate by an opponent or by a colleague in my team, or if a fight arises during the planning of a project? In a challenging situation, what will help me to communicate respectfully and with appreciation? How can I express criticism or irritation honestly, directly and without reproach?<br><br>Nonviolent Communication is a concept developped by Marshall B. Rosenberg, Ph.D., intended to help create an appreciative attitude towards oneself and others, and to live by it. Nonviolent Communication opens paths to express oneself in a mindful and responsible way, so that a bridge can be built even in challenging situations of conflict. Effective and satisfactory cooperation is only possible with well functioning communication between all parties involved, otherwise things will become difficult and inefficient.<br><br>By working with their own examples and anticipating questions that might arise in their future professional lives, the students of Engineering Sciences will be able to reflect their own communicative behavior and learn ways of cooperation and conjoint solution finding. This course will impart the essential competencies of communication necesary for that. |
| **Literature** | German:<br><br>• Rosenberg, Marshall.  (2001) Gewaltfreie Kommunikation. Eine Sprache des Lebens. Junfermann<br>• Rosenberg, Marshall B. und Seils, Gabriele. (15. Auflage 2012) Konflikte lösen durch Gewaltfreie Kommunikation. Ein Gespräch mit Gabriele Seils. Herder Taschenbuch<br>• Larsson, Liv. (2013) 42 Schlüsselunterscheidungen in der GFK. Für ein tieferes Verständnis der Gewaltfreien Kommunikation. Junfermann<br>• De Haen, Nayoma V. und Torsten Hardieß. (2015) 30 Minuten Gewaltfreie Kommunikation. Gabal<br>• Connor, Jane M. und Killian, Dian, Drs. (2014) Verbindung herstellen - Trennendes überbrücken. Mit jedermann, jederzeit und überall eine gemeinsame Ebene finden. Praktische GFK für den Alltag. Junfermann<br>• Dietz, Angela. (2015) Macht ohne Machtwort. Verantwortung übernehmen, Potenziale entfalten. Business Village<br>• Miyashiro, Marie R. (2013) Der Faktor Empathie. Ein Wettbewerbsvorteil für Teams und Organisationen. Junfermann<br>• Brüggemeier, Beate. (2010) Wertschätzende Kommunikation im Business. Wer sich öffnet, kommt weiter. Wie Sie die GFK im Berufsalltag nutzen. Junfermann<br>• Heim, Vera und Lindemann, Gabriele. (2016) Beziehungskompetenz im Beruf. Brücken bauen mit Empathie und Gewaltfreier Kommunikation. Haufe Taschen Guide<br><br>English:<br><br>• Rosenberg, Marshall B., Ph.D. (3rd Edition 2015) Nonviolent Communication: A Language of Life. Create your Life, your Relationships, and your World in Harmony with your Values. Puddledancer Press<br>• Connor, Jane, Ph.D. and Killian, Dian, Ph.D. (2nd edition 2012) Connecting Across Differences: Finding Common Ground with Anyone, Anywhere, Anytime. Puddledancer Press<br>• Miyashiro, Marie R. (2011) The Empathy Factor. Your Competitive Advantage for Personal, Team and Business Success. Puddledancer Press<br>• Roele, Hugo and Rich-Tolsma, Matthew, Drs. (2015) The Book of Needs. A Structural Model for Listening. Kommunikasie.nl<br>• Kashtan, Miki. (2014) Reweaving our Human Fabric. Working Together to Create a Nonviolent Future. Fearless Heart Publications |

| Course L2345: Theory, Research and Practice of University Teaching | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Fachtheoretisch-fachpraktische Arbeit |
| **Examination duration and scale** | Schriftliche Ausarbeitung (in mehreren Teilen) sowie eine Präsentation |
| **Lecturer** | Prof. Christian Kautz, Jenny Alice Rohde |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | This course covers theory and practice of being a student teaching assistant in small-group instructional settings at TUHH.  As part of the seminar, the participants have the opportunity to reflect on their work, e. g. through mutual observation and discussion. |

| | |
|---|---|
| | For prior knowledge / the event requirements:<br><br>This event requires basic first work / collaboration experiences in the academic work structures of a higher education institution, which Master's students have acquired as part of the qualification for the Bachelor's degree at a university.<br><br>These presumed work experiences include specific self-study experiences at a college.<br><br>These are picked up, reflected, expanded and further developed both theoretically and practically with regard to learning from and in groups and later guiding this learning process.<br><br>Furthermore, experiences with different types of learning / group types of higher education, which are part of a degree program acquired during the bachelor's program, are assumed, taken up, reflected on, expanded and further developed here in the master's program.<br><br>The course also requires basic knowledge of presenting scholarly work results obtained by Master's students with a Bachelor's degree.<br><br>In the course, this experience with and in representation in a group situation will be expanded and further developed in the direction of students' involvement with their own role as well as their design in face-to-face interaction as well as in group processes, learning and leadership situations, as masters graduates Graduate unlike bachelor graduates professionally stronger in a moderating role and with the guidance of humans because with the guidance in subject matters are demanded.<br><br>According to the later professional role, the work of the seminar promotes and enables graduate students significantly more than graduates' qualifications for independent work and learning, transferring what they have learned to new areas, contributing, involving discussion and contributing their own examples and interests. |
| **Literature** | **Auszüge aus Fachliteratur zu oben genannten Themen werden in der Veranstaltung ausgegeben.**<br><br>Bandura, A. (1997). Self-efficacy: The exercise of control. New York: Freeman.<br><br>Bosse, E. (2016). Herausforderungen und Unterstützung für gelingendes Studieren: Studienanforderungen<br><br>und Angebote für den Studieneinstieg. In I. van den Berk, K. Petersen, K. Schultes, &<br><br>K. Stolz (Hrsg.). Studierfähigkeit - theoretische Erkenntnisse, empirische Befunde und praktische<br><br>Perspektiven (Bd. 15). (S.129-169). Hamburg: Universität Hamburg.<br><br>Collins, D. & Holton, E. (2004). The effectiveness of managerial leadership development programs: A meta-analysis of studies from 1982 to 2001. Human resource development quarterly, 15(2),<br><br>217 - 248.<br><br>Danielsiek, H., Hubwieser, P., Krugel, J., Magenheim, J., Ohrndorf, L., Ossenschmidt, D., Schaper,<br><br>N. & Vahrenhold, J. (2017). Verbundprojekt KETTI: Kompetenzerwerb von Tutorinnen und Tutoren in der Informatik. In A. Hanft, F. Bischoff, B. Prang (Hrsg.), Working Paper Lehr-/Lernformen. Perspektiven aus der Begleitforschung zum Qualitätspakt Lehre. Abgerufen von KoBF:<br><br>Freeman, S., Eddy, SL., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H. & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematic.<br><br>Proceedings of the National Academy of Sciences 11(23), 8410-8415.<br><br>Glathe, A. (2017). Effekte von Tutorentraining und die Kompetenzentwicklung von MINTFachtutor*<br><br>innen in Lernunterstützungsfunktion. (Nicht veröffentlichte Dissertation). Technische<br><br>Universität Darmstadt, Deutschland.<br><br>Kirkpatrick, D. L. (1959). Techniques for Evaluation Training Program. Journal of the American Society<br><br>of Training Directors, 13, 21-26.<br><br>Hänze, M. Fischer, E. Schreiber, Biehler, R. & Hochmuth, R- (2013). Innovationen in der Hochschullehre:<br><br>empirische Überprüfung eines Studienprogramms zur Verbesserung von vorlesungsbegleitenden<br><br>Übungsgruppen in der Mathematik. Zeitschrift für Hochschulentwicklung, 8(4), 89-<br><br>103.<br><br>Kröpke, H. (2014). Who is who? Tutoring und Mentoring - der Versuch einer begrifflichen Schärfung.<br><br>In D. Lenzen & H. Fischer (Hrsg.), Tutoring und Mentoring unter besonderer Berücksichtigung<br><br>der Orientierungseinheit (Bd. 5). (21-29). Hamburg: Universitätskolleg-Schriften.<br><br>Kühlmann, T. (2007). Fragebögen. In J. Straub, A. Weidemann & D. Weidemann (Hrsg.), Handbuch<br><br>interkulturelle Kommunikation und Kompetenz (346-352). Stuttgart: Metzler.<br><br>Mayring, P. (2010). Qualitative Inhaltsanalyse. Grundlagen und Techniken (11. aktualisierte und überarbeitete<br><br>Auflage). Weinheim/Basel: Beltz. |

Mummendey, H. D. (1981). Methoden und Probleme der Kontrolle sozialer Erwünschtheit (Social

Desirability). Zeitschrift für Differentielle und Diagnostische Psychologie, 2, 199-218.

Rohde, J. & Block, M. (2018). Welche Herausforderungen und Bewältigungsstrategien berichten

Tutor/innen der Ingenieurwissenschaften? Eine explorative Analyse von Reflexionsberichten. Vortrag

auf der 47. Tagung der Deutschen Gesellschaft für Hochschuldidaktik, Karlsruhe.

Heterogenität der Studierenden und Lösungsansätze von Tutor/-innen

Jenny Alice Rohde. Posterpräsentation auf der Tagung “Tutorielle Lehre und Heterogenität”. Technische Universität Darmstadt, 16.05.2019.Hochschuldidaktische Tutorenqualifizierung - Eine Basisqualifizierung des akademischen Nachwuchses und Chance für den Wandel der Lehr-/Lernkultur?

Jenny Alice Rohde & Caroline Thon-Gairola. Posterpräsentation auf der DGHD am 07.03.2019.Welches Lehrverhalten zeigen geschulte Tutor/innen? Eine explorative Analyse selbst- und fremdwahrnehmungsbasierter Reflexionsberichte

Jenny Alice Rohde & Nadine Stahlberg. In: die hochschulehre (2019).

Schneider, M. & Preckel, F. (2017). Variables associated with achievement in higher education: A

systematic review of meta-analyse. Psychological Bulletin, 143(6), 565-600.

Skylar Powell, K. & Yalcin, S. (2010). Managerial training effectiveness: A meta-analysis 1952-2002.

Personnel Review, 39(2), 227-241.

27 Welches Lehrverhalten zeigen geschulte Tutor/innen

d ie hochs chul l ehre 2019 www.hochschullehre.org

Stes, A., Min-Leliveld, M., Gijbels, D. & Van Petegem, P. (2010). The impact of instructional development

in higher education: The state-of-the-art of the research. Educational Research Review,

5(1), 25-49.

Stroebe, W. (2016). Why Good Teaching Evaluations May Reward Bad Teaching: On Grade Inflation

and Other Unintended Consequences of Student Evaluation. Perspectives on Psychological Science,

11(6), 800-816.

Technische Universität Hamburg (2018). Kennzahlen 2017. Hamburg: Technische Universität Hamburg.

[https://www.tuhh.de/tuhh/uni/informationen/kennzahlen.html]

Thumser-Dauth, K. (2008). Und was bringt das? Evaluation hochschuldidaktischer Weiterbildung.

In B. Berendt, H.-P. Voss & J. Wildt (Hrsg.), Neues Handbuch Hochschullehre. Lehren und Lernen

effizient gestalten. Kap. L 1.11 Hochschuldidaktische Aus- und Weiterbildung. Veranstaltungskonzepte

und -modelle. Berlin: Raabe. S. 1-10.

Wibbecke, G. (2015): Evaluation einer hochschuldidaktischen Weiterbildung an der Medizinischen

Fakultät Heidelberg. Dissertation. Ruprecht-Karls-Universität Heidelberg.

Willige, J., Woisch, A., Grützmacher, J. & Naumann, H. (2015a). Randauszählung Studienqualitätsmonitor

2014, Technische Universität Hamburg-Harburg, Online-Befragung Studierender im

Sommersemester 2014, DZHW - Deutsches Zentrum für Hochschul- und Wissenschaftsforschung.

Willige, J., Woisch, A., Grützmacher, J. & Naumann, H. (2015b). Randauszählung Studienqualitätsmonitor

2015, Technische Universität Hamburg-Harburg, Online-Befragung Studierender im

Sommersemester 2015, DZHW - Deutsches Zentrum für Hochschul- und Wissenschaftsforschung.

Winkler, M. (2018). Tutorielle Lehransätze im Vergleich. Die KOMPASS Begleitforschung. Vortrag

gehalten am 12.03.2018 auf dem Netzwerktreffen Tutorienarbeit an Hochschulen in Würzburg.

Zech, F. (1977). Grundkurs Mathematikdidaktik: theoretische und praktische Anleitungen für das

Lehren und Lernen im Fach Mathematik. Weinheim: Beltz.

| Course L1509: Intercultural Communication | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Prof. Margarete Jarchow, Anna Katharina Bartel |
| **Language** | EN |
| **Cycle** | WiSe/SoSe |
| **Content** | As young professionals with technical background you may often tend to focus on communicating numbers and statistics in your presentations. However, facts are only one aspect of convincing others. Often, your personality, personal experience, cultural background and emotions are more important. You have to convince as a person in order to get your content across.<br><br>In this workshop you will learn how to increase and express your cultural competence. You will apply cultural knowledge and images in order to positively influence communicative situations. You will learn how to add character and interest to your talks, papers and publications by referring to your own and European Cultural background. You will find out the basics of communicating professionally and convincingly by showing personality and by referring to your own cultural knowledge. You will get hands-on experience both in preparing and in conducting such communicative situations. This course is not focussing on delivering new knowledge about European culture but helps you using existing knowledge or such that you can gain e.g. in other Humanities courses.<br><br>Content<br><br>• How to enrich the personal character of your presentations **by referring to European and your own culture**<br>• How to properly arrange **content and structure.**<br>• How to use **PowerPoint for visualization** (you will use computers in an NIT room).<br>• How to be well-prepared and convincing **when delivering** your thoughts to your audience**.** |
| **Literature** | Literaturhinweise werden zu Beginn des Seminars bekanntgegeben.<br><br>Literature will be announced at the beginning of the seminar. |

| Course L2015: Intercultural Management - Theory and Awareness Training | |
|---|---|
| **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** | 15 Minuten Vortrag und dessen schriftliche Ausarbeitung (10 Seiten) |
| **Lecturer** | Prof Jürgen Rothlauf |
| **Language** | EN |
| **Cycle** | WiSe/SoSe |
| **Content** | The subject of the course is the deepening of the intercultural dimension of international management in relation to fundamental challenges, the importance of culture in team work and leadership of large multinational companies. In addition, culture-awareness trainings are discussed and carried out. |
| **Literature** | Rothlauf, J (2014): A Global View on Intercultural Management - Challenges in a Globalized World, De Gruyter Oldenbourg Verlag, 360 p |

| Course L2346: Young, educated, (non)political - are our young engineers well prepared for the future? | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Vincent-Immanuel Herr |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | Digitalization, climate change, democracy - society is facing fundamental upheavals. The next generation of young engineers in particular must no longer remain out of debate and can provide answers to the big questions of our time. Why is social commitment important? Is studying preparing us well for the future? What needs to improve? In the interactive workshop, the participants will be accompanied in analyzing their own generation and their own actions and in developing thesis on how to improve technical studies and training. The result of the seminar will be a joint thesis paper. |
| **Literature** | Wird im Seminar bekannt gegeben. |

| Course L2176: Culture of Communication - Theories and Methods of Successful Communication | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Anna Katharina Bartel |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | This course is for master students. In this seminar, we will explore different theories, models and methods from the fields of communication, psychology and cultural theory.<br><br>The participants will work on theoretical content and do group presentations. They will also use examples from their own experiences to apply models and methods in practical exercises.<br><br>The way we communicate shapes the way we experience our relationships, in the business world as well as in our private lives. We spend an overwhelming amount of time in group situations. This makes it worthwhile to explore how communication works within the group context and how, within these different groups, different cultures of communication develop. This particularly applies in highly specialized fields, such as engineering.<br><br>Our ability to flexibly and successfully move from one context to another helps us along in building successful careers and allows us to feel positive about our private lives.<br><br>However, this is not always simple. For example:<br><br> If we are part of a context in which many conflicts arise<br><br> If we have to switch between different contexts frequently<br><br> Or if, on the one hand, complicated facts and data are our main focus but on the other hand, we have to communicate them to people who are not familiar with the subject. Maybe we even have to win their attention in order to help along our causes.<br><br>Oftentimes, this leads to misunderstandings. There also might be a lack of openness or willingness to embrace conflict. This might make it difficult for us to reach our goals. To be able to reflect on the way we communicate, to identify patterns of communication and the ability to actively build positive relationships through communication are useful skills to help overcome those obstacles.. |
| **Literature** | • Knoblauch, H. (1995). Kommunikationskultur: Die kommunikative Konstruktion kultureller Kontexte (Materiale Soziologie, Band 5). de Gruyter.<br>• Geert Hofstede, Geert Jan Hofstede, Michael Minkov. (2010). Cultures and Organizations - Software Of The Mind:Intercultural Cooperation and Its Importance for Survival. McGraw-Hill Education.<br>• Bay, Rolf H. (2006) Erfolgreiche Gespräche durch aktives Zuhören. Ehningen. Expert-Verlag.<br>• Cohn, Ruth (1975). Von der Psychoanalyse zur Themenzentrierten Interaktion. Stuttgart. Klett - Cotta<br>• Fengler, Jörg (1998) Feedback geben. Weinheim. Beltz.<br>• Lumma, Klaus (2006). Die Teamfibel oder das Einmaleins der Team- & Gruppenqualifizierung im sozialen und betrieblichen Bereich. Windmühle.<br>• Spies, Stefan. (2010). Der Gedanke lenkt den Körper: Körpersprache - Erfolgsstrathegien eines Regisseurs. Hoffmann und Campe. |

| Course L0535: Theory of Communication | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | 20-30 Minuten Referat und Thesenpapier |
| **Lecturer** | Dr. Michael Florian |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The seminar focuses on sociological theories of communication and selected problems of practical application in the area of crisis communication. The issue of crisis communication will be analyzed on the basis of case studies. |
| **Literature** | Habermas, Jürgen (1981): Theorie des kommunikativen Handelns. 2 Bände. Frankfurt/Main: Suhrkamp.<br>Luhmann, Niklas (1984): Soziale Systeme. Grundriß einer allgemeinen Theorie. Frankfurt/Main: Suhrkamp.<br>Malsch, Thomas (2005): Kommunikationsanschlüsse. Zur soziologischen Differenz von realer und künstlicher Sozialität. Wiesbaden: VS Verlag für Sozialwissenschaften.<br>Malsch, Thomas; Schmitt, Marco (Hg.) (2014): Neue Impulse für die soziologische Kommunikationstheorie. Empirische Widerstände und theoretische Verknüpfungen. Springer Fachmedien: Wiesbaden.<br>Meckel, Miriam; Schmid, Beat F. (Hg.) (2008): Unternehmenskommunikation. Kommunikationsmanagement aus Sicht der Unternehmensführung. 2., überarbeitete und erweiterte<br>Auflage. Gabler GWV Fachverlage: Wiesbaden.<br>Merten, Klaus (1999): Einführung in die Kommunikationswissenschaft. Bd 1/1: Grundlagen der Kommunikationswissenschaft. Münster: Lit Verlag.<br>Nolting, Tobias; Thießen, Ansgar (Hg.) (2008): Krisenmanagement in der Mediengesellschaft. Potenziale und Perspektiven der Krisenkommunikation. Wiesbaden: VS Verlag für Sozialwissenschaften.<br>Schützeichel, Rainer (2004): Soziologische Kommunikationstheorien. Konstanz: UVK Verlagsgesellschaft.<br>Thießen, Ansgar (2011): Organisationskommunikation in Krisen. Reputationsmanagement durch situative, integrierte und strategische Krisenkommunikation. VS Verlag für Sozialwissenschaften/Springer Fachmedien: Wiesbaden.<br>Thießen, Ansgar (Hg.) (2013): Handbuch Krisenmanagement. Springer Fachmedien: Wiesbaden. |

| Course L1732: criminology and society - in German | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | Gruppenreferat (30 bis 45 Minuten, Eigenanteil je Person 10 bis 15 Minuten) inkl. schriftlicher Ausarbeitung, Ggf. alternativ eine längere, schriftliche Ausarbeitung. |
| **Lecturer** | Sarah Schirmer |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | The seminar will provide an overview of Criminology and introduce different theories of criminality. It is necessary to consider the discipline of Criminology within its historical context in order to understand how some theories have evolved. The students will use this knowledge of Criminology theory to discuss and consider the advantages and disadvantages of each theory. Discussions will include how society constructs crime as well as a more philosophical debate about a determined view. |
| **Literature** | Wird zeitnah bekannt gegeben.<br><br>Will be announced in lecture. |

| Course L2369: Literature and Culture for international students of Master's degree programs in English (non-native speakers of German) | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 4 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 64, Study Time in Lecture 56 |
| **Examination Form** | Referat |
| **Examination duration and scale** | 45 min. Präsentation und anschließende Diskussion |
| **Lecturer** | Bertrand Schütz |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | The seminar LITERATURE AND CULTURE investigates what culture is, especially what characterises epistemic cultures.<br><br>Culture is to be understood as the creative response to a given situation and the capacity to integrate inputs and influences, therefore as an ongoing process of permanent readjustment and learning, and by no means as a fixed identity in terms of an “essence”.<br><br>There is a growing awareness that Europe cannot lay claim to possess the ultimate standards of knowledge.<br><br>A topography of our contemporary world is to be sketched by highlighting its historical and cultural premises.<br><br>For more information please refer to the German description and the StudIP. |
| **Literature** | Je nach Thematik des Semesters wird eine spezifische<br>Literatur-Liste erstellt.<br><br>cf. StudIP |

| Course L1837: People in Business Organizations | |
|---|---|
| **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** | Schriftliche Hausarbeit 7-10 Textseiten; verpflichtend: Präsentation der Zwischenergebnisse mit Diskussion (geht nicht in die Bewertung mit ein) |
| **Lecturer** | Dr. Martin Schütz |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | The influence of technological change and social change on business organizations - how to manage the organizational change. |
| **Literature** | Becker, Karen Louise (2007): Unlearning in the workplace. A mixed methods study. PhD. Queensland University of Technology, Brisbane. Faculty of Education. Online verfügbar unter http://eprints.qut.edu.au/16574/.<br><br>Frey, Dieter; Gerkhardt, Marit; Peus, Claudia; Traut-Mattausch, Eva; Fischer, Peter (2014): Veränderungen managen. Widerstände und Erfolgsfaktoren der Umsetzung. In: Lutz von Rosenstiel, Erika Regnet und Michel E. Domsch (Hg.): Führung von Mitarbeitern. Handbuch für erfolgreiches Personalmanagement. 7. Aufl. Stuttgart: Schäffer-Poeschel, S. 547-559.<br><br>Hauser, Berndhard (2014): Konflikte in und zwischen Gruppen. In: Lutz von Rosenstiel, Erika Regnet und Michel E. Domsch (Hg.): Führung von Mitarbeitern. Handbuch für erfolgreiches Personalmanagement. 7. Aufl. Stuttgart: Schäffer-Poeschel, S. 354-367.<br><br>Kieser, Alfred; Walgenbach, Peter (2007): Organisation. 5. Aufl. Stuttgart: Schäffer-Poeschel.<br><br>Miebach, Bernhard (2012): Organisationstheorie. Problemstellung - Modelle - Entwicklung. 2. Aufl. Wiesbaden: Springer Fachmedien Wiesbaden; Imprint: Springer VS.<br><br>Müller, Ursula (Hg.) (2013): Geschlecht und Organisation. Wiesbaden: Springer VS (Geschlecht und Gesellschaft, 45).<br><br>Olfert, Klaus (2012): Organisation. 16. Aufl. Herne: NWB Verlag.<br><br>Pohlmann, Markus; Markova, Hristina (2011): Soziologie der Organisation. Eine Einführung. Konstanz, München: UVK-Verl.-Ges. (3573).<br><br>Preisendörfer, Peter (2011): Organisationssoziologie. Grundlagen, Theorien und Problemstellungen. 3. Aufl. Wiesbaden: VS Verlag für Sozialwissenschaften.<br><br>Robbins, Stephen P.; Judge, Timothy A. (2013): Organizational Behavior. 15. Aufl. Boston, Mass: Pearson.<br><br>Rosenstiel, Lutz von; Nerdinger, Friedemann W. (2011): Grundlagen der Organisationspsychologie. Basiswissen und Anwendungshinweise. 7. Aufl. Stuttgart: Schäffer-Poeschel.<br><br>Sanders, Karin; Kianty, Andrea (2006): Organisationstheorien. Eine Einführung. 1. Aufl. Wiesbaden: VS Verlag für Sozialwissenschaften.<br><br>Schreyögg, Georg (2008): Organisation. Grundlagen moderner Organisationsgestaltung, mit Fallstudien. 5. Aufl. Wiesbaden: Gabler (Lehrbuch).<br><br>Vahs, Dietmar (2012): Organisation. Ein Lehr- und Managementbuch. 8. Aufl. Stuttgart: Schäffer-Poeschel.<br><br>Weinert, Ansfried B. (2004): Organisations- und Personalpsychologie. 5. Aufl. Weinheim: BeltzPVU. |

| Course L1846: Classical Journalism and New Media | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | Ca. 20 min. plus anschließende Diskussion |
| **Lecturer** | Dieter Bednarz |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | The world wide walkover of the internet dramatically changed the perception of classical media like newspapers, magazines and even TV. In this seminar the reasons of and the consequences for the dramatic changes regarding our information habits will be analyzed and discussed. Has the media expert Neil Postman been right, when he one said, that we all one day will be „overnewsed but underinformed“?<br><br>Keeping a close eye on the real challenges of journalism, the seminar will discuss the standards of ethics in politics and media. |
| **Literature** | Wird im Seminar genannt |

| Course L1023: Politics | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Dr. Stephan Albrecht |
| **Language** | EN |
| **Cycle** | WiSe/SoSe |
| **Content** | Scientists and engineers neither just strive for truths and scientific laws, nor are they working in a space far from politics. Science and engineering have contributed to what we now call the Anthropocene, the first time in the history of mankind when essential cycles of the earth system, e.g. carbon cycle, climate system, are heavily influenced or even shattered. Furthermore, Peak oil is indicating the end of cheap fossil energy thus triggering the search for alternatives such as biomass.<br><br>Systems of knowledge, science and technology in the OECD countries have since roughly 30 years increasingly become divided. On the one hand new technologies such as modern biotechnology, IT or nanotechnology are developing rapidly, bringing about many innovations for industry, agriculture, and consumers. On the other hand scientific studies from earth, environmental, climate change, agricultural and social sciences deliver increasingly robust evidence on more or less severe impacts on society, environment, global equity, and economy resulting from innovations during the last 50 years. Technological innovation thus is no longer an uncontested concept. And many protest movements demonstrate that the introduction of new or the enlargement of existing technologies (e.g. airports, railway stations, highways, high-voltage power lines surveillance) isn’t at all a matter of course.<br><br>It is important to bear in mind the fact that all processes of technological innovation are made by humans, individually and collectively. Industrial, social, and political organizations as actors from the local to global level of communication, deliberation, and decision making interact in diverse arenas, struggling to promote their respective corporate and/or political agenda. So innovations are as well a problem of technology as a problem of politics. Innovation and technology policies aren’t the same in all countries. We can observe conceptual and practical variations.<br><br>Since the 1992 Earth Summit in Rio de Janeiro Agenda 21 constitutes a normative umbrella, indicating Sustainable Development (SD) as core cluster of earth politics on all levels from local to global. Meanwhile other documents such as the Millennium Development Goals (MDG) have complemented the SD agenda. SD can be interpreted as operationalization of the Universal Declaration of Human Rights, adopted in 1948 by the General Assembly of the United Nations and since amended many times.<br><br>Engineers and scientists as professionals can’t avoid to become confronted with many non-technical and non-disciplinary items, challenges, and dilemmas. So they have to choose between alternative options for action, as individuals and as members of organizations or employees. Therefore the seminar will address core elements of the complex interrelations between science, society and politics. Reflections on experiences of participants - e.g. from other countries as Germany - during the seminar are very welcome.<br><br>The goals of the seminar include:<br><br>• Raising awareness and increasing knowledge about the political implications of scientific work and institutions;<br>• Improving the understanding of different concepts and designs of innovation and technology policies;<br>• Increasing knowledge about the status and perspectives of sustainable development as framework concept for technological and scientific progress;<br>• Understanding core elements of recent arguments, conflicts, and crises on technological innovations, e.g. geo-engineering or bio-economy;<br>• Improving the understanding of scientists’ responsibility for impacts of their professional activities;<br>• Embedding individual professional responsibility in social and political contexts.<br><br>The seminar will deal with current problems from areas such as innovation policy, energy, food systems, and raw materials. Issues will include the future of energy, food security and electronics. Historical issues will also be addressed.<br><br>The seminar will start with a profound overarching introduction. Issues will be introduced by a short presentation and a Q & A session, followed by group work on selected problems. All participants will have to prepare a presentation during the weekend seminar. The seminar will use inter alia interactive tools of teaching such as focus groups, simulations and presentations by students. Regular and active participation is required at all stages. |
| **Literature** | Literatur wird zu Beginn des Seminars abgesprochen. |

| Course L1856: Politics and Science - in German | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | Referat ca. 20 min. plus anschließende Diskussion |
| **Lecturer** | Dr. Mirko Himmel, Dr. Ines Krohn-Molt |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | Scientists often like to believe that their work is non-political. Within this seminar we want to demonstrate how deeply both are interconnected and converged. Not only, scientific guidance is often needed to take a political decision but also scientific outcomes are a sub-ject to political interpretation. Also, politics are significantly influencing scientific progress by framing research agendas and by funding decisions. |
| **Literature** | Wird im Seminar genannt |

| Course L1779: Politics and Science - in English | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Dr. Frederik Postelt, Dr. Gunnar Jeremias |
| **Language** | EN |
| **Cycle** | WiSe/SoSe |
| **Content** | Scientists often like to believe that their work is non-political. Within this seminar we want to demonstrate how deeply both are interconnected and converged. Not only, scientific guidance is often needed to take a political decision but also scientific outcomes are a sub-ject to political interpretation. Also, politics are significantly influencing scientific progress by framing research agendas and by funding decisions.<br><br>During this seminar we would like to show the different range of influences - scientific, economic, social, environmental, ethical/normative, security-related - affecting decision-making on science and politics. Using case studies on current debates on food security, public health, nuclear energy and terrorism to discuss the interrelation between science and politics illuminating the role of various actors in this process, such as:<br><br>• Governments,<br><br>• International organizations,<br><br>• Scientific associations,<br><br>• Industry,<br><br>• Civil society, and<br><br>• Individual scientists.<br><br>The guiding questions will be:<br><br>• How does and should science influence politics?<br><br>• How does and should politics influence science?<br><br>In order to take responsibility for the consequences of scientific work, engineers and scientists increasingly need to acknowledge the political dimension of their work and their role in the political process. We will address this political dimension of scientific work by discussing:<br><br>• Biographies and motivations of famous scientists,<br><br>• Individual responsibility of scientists for the implications of their work, and<br><br>• The role of codes of conduct as guidelines for responsible behaviour.<br><br>The goals of the seminar include:<br><br>• Raising awareness and increasing knowledge about the political dimensions of scientific work,<br><br>• Providing guidelines for evaluating political implications of scientific research,<br><br>• Improving the understanding of scientists' and engineers' responsibility for the results of their professional activities,<br><br>• Taking decisions at the institutional, national and international level about rules and regulations concerning scientific conduct, and<br><br>• Choosing arguments and defending positions in situations of conflicting interests.<br><br>The seminar will use current issues, such as dilemmas in the life sciences or bio fuels to demonstrate the problematic relationship between science and politics. The seminar, however, does not focus on providing in-depth knowledge of these current issues. We strongly discourage students that have participated in an "Ethics for Engineers" seminar to take this course, because the contents of the two seminars overlap.<br><br>Issues will be introduced by short presentations and a Q&A session, followed by group work on selected problems. All participants will have to prepare a presentation. Those requiring a graded certificate ("Schein") additionally have to write a 3-4 page paper on selected issues. The seminar will use interactive tools of teaching such as role playing and simulations. Group work and active participation is expected at all stages of the seminar. |
| **Literature** | will be announced in lecture<br><br>wird im Seminar bekannt gegeben |

| Course L1734: Projectrealisation: TUHH goes circular - Sustainability in Research, Education and campus management | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | EN |
| **Cycle** | WiSe/SoSe |
| **Content** | |
| **Literature** | Wird im Seminar bekanntgegeben<br><br>Will be announced in lecture. |

| Course L1872: Social Learning: Social Commitment in Refugee Issues / Master | |
|---|---|
| **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 Seiten |
| **Lecturer** | Muthana Al-Temimi |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | folgt |
| **Literature** | Wird im Seminar bekannt gegeben.<br><br>Will be announced in lecture. |

| Course L1647: Soft skill seminar for dual study programme (dual@TUHH) / Master | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | Referat mit 2-3 Videoübungen à 20 Minuten + anschließende Diskussion |
| **Lecturer** | Silke Wolckenhaar-Wagner, Dr. Henning Haschke |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | |
| **Literature** | |

| Course L1771: The Arabic Spring an its Consequences | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Dieter Bednarz |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | The world wide walkover of the internet dramatically changed the perception of classical media like newspapers, magazines and even TV. In this seminar the reasons of and the consequences for the dramatic changes regarding our information habits will be analyzed and discussed:<br><br>Taking a close look at the Middle East the political impact of the new media´s triumphal procession will be assessed and evaluated. How come that Twitter and Facebook on one hand facilitated the so called Arabic Spring and caused hope for the rise of democracy in the region, while on the other hand the revolutionaries failed so dramatically - at least for now.<br><br>Keeping a close eye on both fields, the Media and the Middle East, the seminar will discuss the standards of ethics in politics and journalism. |
| **Literature** | Wird im Seminar angegeben und besprochen.<br><br>Will be announced in the lecture. |

| Course L1916: Responsible Conduct in Technology & Science | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Dr. Mirko Himmel, Dr. Ines Krohn-Molt |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | Aim of the seminar is raising awareness for the responsibility of engineers and researchers for a proper and ethical conduct in technology and science. The Participants will present and discuss practical examples for good as well as bad conduct in science. |
| **Literature** | folgt im Seminar |

| Course L1991: What can philosophy do? | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Dr. Ursula Töller |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | Over the centuries, the philosophy is lined up as a discipline that provides complex and universal answers to contemporary history and circumstances. Often, she could design utopias that have led the way for political upheaval. While all scientific disciplines are subject to an increasing differentiation, the philosophy in the second half of the 20th century has lost its claim to universality. But what then are the topics of the philosophy of the 20th and 21st century and what impact have philosophical theories for processes of change?<br><br>We will provide an overview of Western philosophies of the 20th and 21st century. and take a critical look at the self-understanding of philosophy. |
| **Literature** | Gerhardt Schweppenhäuser: Kritische Theorie, Stuttgart 2010<br><br>Postmoderne und Dekonstruktion, Texte französischer Philosophen der Gegenwart, hrsg. von Peter Engelmann, Reclam UB 8668<br><br>Thomas Rentsch: Philosophie des 20. Jhdts. Von Husserl bis Derrida, München 2014<br><br>Geschichte der Philosophie in Text und Darstellung, Bd. 8=20 Jhdt.<br><br>Reclam UB 9918<br><br>Geschichte der Philosophie in Text und Darstellung, Bd. 9= Gegenwart<br><br>Reclam UB 18267 |

| Course L2343: Academic Writing and Presentation for Master-Students | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Referat |
| **Examination duration and scale** | etwa 20 Minuten Präsentation und 10-20 Minuten Diskussion |
| **Lecturer** | Dr. Ursula Töller |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | The course is aimed at Master students who are planning to write their thesis, want to pursue their PhD or intend to present their research results at conferences and in journals. The course is structured on three levels: 1. writing, 2. presenting and 3. interacting in organizational structures. The latter refers to the work environment at university as well as in research groups and enterprises. In the course of the seminar, the participants become acquainted with various methods and theories on the subject. Furthermore, the methods and theories will be put into practice, reflected upon and discussed as part of the seminar. |
| **Literature** | • Umberto Eco, Wie man eine wiss. Abschlussarbeit schreibt (2010)<br>• Helga Esselborn-Krumbiegel, Von der Idee zum Text. Eine Anleitung zum wissenschaftlichen Schreiben (2008)<br>• Tony Buzan: Das Mind-Map-Buch. (2001)<br>• John W. Chinneck: How to organize your Thesis (1999)<br>• Lothar Seiwert: Das neue 1x1 des Zeitmanagements (2003)<br>• Steven R. Covey: Die sieben Wege der Effektivität (2000)<br>• Harold Kerzner: Twenty Common Mistakes Made by New or Inexperienced Project Manager (2010)<br>• Friedemann Schulz von Thun: Miteinander Reden. (1996)<br><br>Tim McClintock: Dealing with Specific Types of Difficult People.<br><br>(2008) |

| Course L2029: “Lying press”? Functions and current challenges of journalism | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Mündliche Prüfung |
| **Examination duration and scale** | 20 min |
| **Lecturer** | Prof. Horst Pöttker |
| **Language** | DE |
| **Cycle** | WiSe/SoSe |
| **Content** | Lying press - there is a revival of the disparaging invective. Journalists use to shoot it down by leading it back to its supposed roots in the NS-propaganda. This is less convincing as several parties and ideologies have used it since the middle of the 19$^{th}$ century to discredit the media of other parties and ideologies. And it is missing the core of the problem. Critics are reasonably afraid that the choice of “lying press” to the “non-word of the year” 2014 has blocked the question, if there is a justified criticism of information media and journalism - or more precisely of the relationship between journalism and its audience. If this is the case both - journalism and audience - are involved from the perspective of inter actionism.<br><br>Against this background interactive instructions will be given by scholarly literature and practical examples from the German and international media business.<br><br>Questions like the following will be discussed:<br><br>• Is journalism really a profession? If so - since when?<br>• What is journalism for? (task and duties, functions, self-images)<br>• Do the audience and journalists themselves have a reasonable understanding of tasks, functions, practices, problems of journalism?<br>• What is the current concept of journalistic professionalism? Has it ever been the same?<br>• From an international perspective: Does journalism in Germany have special shortcomings - if so, how can they be removed?<br>• What are the economic challenges for journalism from the digital media upheaval?<br>• In which direction do journalistic professionalism and self-understanding change in the digital media world?<br><br>Objective is solid learning about professional tasks, ethics, techniques, endagerments, history and current problems of journalism including science journalism. |
| **Literature** | Zur Einführung:<br><br>Lilienthal, Volker/Neverla, Irene (Hrsg.) (2017): „Lügenpresse“. Anatomie eines politischen Kampfbegriffs. Köln: Kiepenheuer & Witsch. https://www.kiwi-verlag.de/buch/luegenpresse/978-3-462-31782-4/<br><br>Pöttker, Horst (2010): Der Beruf zur Öffentlichkeit. Über Aufgabe, Grundsätze und Perspektiven des Journalismus in der Mediengesellschaft aus der Sicht praktischer Vernunft. In: Publizistik, 55. Jg., H. 2, S. 107-128. https://www.springerprofessional.de/en/der-beruf-zur-oeffentlichkeit/5889108<br><br>Weischenberg, S. (2007): Das *Jahrhundert des Journalismus* ist vorbei. Rekonstruktionen und Prognosen zur Formation gesellschaftlicher Selbstbeobachtung. In: *Bartelt-Kircher*, G. et al.: Krise der Printmedien - eine Krise des Journalismus? Berlin und New York, de Gruyter Saur, S. 32-60.<br><br>https://medien21.wordpress.com/2011/10/17/weischenberg-das-jahrhundert-des-journalismus-ist-vorbei/<br><br>Eine ausführliche Literaturliste wird am Anfang des Seminars verteilt. |

## Module M0554: Quantitative Methods - Statistics and Operations Research

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Quantitative Methods - Statistics and Operations Research (L0127) | Lecture | 3 | 4 |
| Quantitative Methods - Statistics and Operations Research (L0250) | Recitation Section (large) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Kathrin Fischer |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Knowledge of Mathematics on the Bachelor Level. 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<br>• different methods from the field of descriptive statistics and can explain them and their importance for Business Analysis;<br>• different discrete and continuous distribution functions and can explain their meaning and their areas of application<br>• the laws of probability theory as, e.g. the Bayes rule, and can explain them;<br>• different methods of oinferential statistics - e.g. confidence intervals, hypothesis testing and regression analysis - and can explain their theoretical background;<br>• fields of research in which statistical methods are applied;<br>• the history and relevance of Operations Research;<br>• linear programming methods for solving planning problems and can explain them;<br>• selected methods of transportation and network optimization amd can explain them;<br>• integer programming models and methods, e.g. for location planning;<br>• appropriate software for solving these problems;<br>• relevant areas of OR research. |
| *Skills* | Students are able to<br>• collect empirical data by appropriate methods, to aggregate, classify and analyze the data and to draw conclusions from them also in complex and realistic situations, e.g. for time series;<br>• recognize different distribution functions and to apply them in the solution of Business problems;<br>• apply laws of probability, as e.g. the Bayes rule, to construct solutions for Business and Engineering problems;<br>• select appropriate methods of inferential statistics, apply them to Business problems and evaluate the results of their analysis;<br>• construct appropriate quantitative - linear or integer - models for Business and Engineerig planning situations;<br>• apply methods from linear and integer programming and interpret and evaluate the results;<br>• apply methods from transport and network planning and interpret and evaluate the results;<br>• solve the problems with appropriate software, carry out sensitivity analyses and evaluate the results;<br>• develop a critical judgement of the different methods and their applicability;<br>• use models and methods from Statistics and OR to analyse problems from the areas of business and engineering and to evaluate the results;<br>• apply their theoretical knowledge of the different methods to practical problems, in particular in international value chains and also to apply their knowledge to specific research problems. |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>• engage in scientific discussions on topics from the fields of Statistics and OR;<br>• present the results of their work to specialists;<br>• work successfully and respectfully in a team. |
| *Autonomy* | Students are able to<br>• carry out complex data analyses independently, individually or in a team;<br>• solve complex Business planning problems independently or in a team, selecting and using appropriate software;<br>• gather knowledge in the area independently and research-based, and to apply their knowledge also in new and unknown situations;<br>• critically evaluate the results of their work and the consequences. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>Yes / 2.5 % / Excercises /<br>Yes / 47.5 % / Midterm / |
| **Examination** | Written exam |
| **Examination duration and scale** | 3 hours |
| **Assignment for the Following Curricula** | International Management and Engineering: Core Qualification: Compulsory |

| Course L0127: Quantitative Methods - Statistics and Operations Research | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Kathrin Fischer |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | **Statistics**<br><br>• Descriptive Statistics: Graphical representations, calculation of relevant measures of central tendency etc., also by using a computer; application of methods for large data sets, analysis and comparison of results, critical discussion and evaluation of methods and their use in scientific projects and business practice<br>• Probability theory: important laws, dependent probabilities, Bayes Rule; application to practical problems<br>• Use and application of probability distributions , as e.g. Binomial and Normal distribution to Management and Engineering problems<br>• Methods of inferential statistics: confidence intervals: theoretical background and applications; hypothesis testing: theoretical background and application to business problems; regression analysis: theoretical background and application in research practice.<br><br>**Operations Research**<br><br>• Linear Programming: Modelling business decision situations, solving problems by Simplex method and by using software, theoretical background of Simplex procedure, Dual Simplex procedure and blocked variables, special cases (degeneracy etc.); sensitivity analysis and interpretation<br>• Transportation planning: Modellung transportation and transshipment problems in global networks; Solving transportation problems using software<br>• Network Optimization problems: modelling production and transportation networks, solving planning problems in networks, Network Planning as a research topic<br>• Integer Programming: Models using integer variables, e.g. in location decisions, branch and bound procedure |
| **Literature** | Ausgewählte Bücher:<br><br>D.R. Anderson / D.J. Sweeney / T.A. Williams / Martin: Quantitative Methods for Business. 11th Edition, Thomson, South Western 2008.<br><br>Bluman, Alan G.: Elementary Statistics - A brief version. Third Edition, McGrawHill 2006.<br>Bowerman, Bruce L. and O'Connell, Richard T.: Business Statistics in Practice, 8th edition, McGraw-Hill 2016.<br><br>Domschke, W., Drexl, A.: Einführung in Operations Research, 9. Auflage, Springer, Berlin et al. 2015.<br><br>Domschke, W. / A. Drexl / R. Klein / A. Scholl / S. Voß: Übungen und Fallbeispiele zum Operations Research, 8. Auflage, Springer, Berlin et al. 2015<br><br>Hillier, F.S., Lieberman, G.J.: Introduction to Operations Research. 11th Edition, McGraw-Hill, 2014.<br><br>Schira, J.: Statistische Methoden der VWL und BWL - Theorie und Praxis. 5. Auflage, Pearson Verlag 2016.<br><br>Zudem: Skript und Unterlagen, die zur Vorlesung herausgegeben werden. |

| Course L0250: Quantitative Methods - Statistics and Operations Research | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kathrin Fischer |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | **Statistics**<br><br>• Descriptive Statistics: Graphical representations, calculation of relevant measures of central tendency etc., also by using a computer; application of methods for large data sets, analysis and comparison of results, critical discussion and evaluation of methods and their use in scientific projects and business practice<br>• Probability theory: important laws, dependent probabilities, Bayes Rule; application to practical problems<br>• Use and application of probability distributions , as e.g. Binomial and Normal distribution to Management and Engineering problems<br>• Methods of inferential statistics: confidence intervals: theoretical background and applications; hypothesis testing: theoretical background and application to business problems; regression analysis: theoretical background and application in research practice.<br><br>**Operations Research**<br>• Linear Programming: Modelling business decision situations, solving problems by Simplex method and by using software, theoretical background of Simplex procedure, Dual Simplex procedure and blocked variables, special cases (degeneracy etc.); sensitivity analysis and interpretation<br>• Transportation planning: Modellung transportation and transshipment problems in global networks; Solving transportation problems using software<br>• Network Optimization problems: modelling production and transportation networks, solving planning problems in networks, Network Planning as a research topic<br>• Integer Programming: Models using integer variables, e.g. in location decisions, branch and bound procedure |
| **Literature** | Ausgewählte Bücher:<br><br>D.R. Anderson / D.J. Sweeney / T.A. Williams / Martin: Quantitative Methods for Business. 11th Edition, Thomson, South Western 2008.<br><br>Bluman, Alan G.: Elementary Statistics - A brief version. Third Edition, McGrawHill 2006.<br>Bowerman, Bruce L. and O’Connell, Richard T.: Business Statistics in Practice, 8th edition, McGraw-Hill 2016.<br><br>Domschke, W., Drexl, A.: Einführung in Operations Research, 9. Auflage, Springer, Berlin et al. 2015.<br><br>Domschke, W. / A. Drexl / R. Klein / A. Scholl / S. Voß: Übungen und Fallbeispiele zum Operations Research, 8. Auflage, Springer, Berlin et al. 2015<br><br>Hillier, F.S., Lieberman, G.J.: Introduction to Operations Research. 11th Edition, McGraw-Hill, 2014.<br><br>Schira, J.: Statistische Methoden der VWL und BWL - Theorie und Praxis. 5. Auflage, Pearson Verlag 2016.<br><br>Zudem: Skript und Unterlagen, die  zur Vorlesung herausgegeben werden. |

## Module M0820: International Business

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Business-to-Business Marketing (L0762) | Lecture | 2 | 2 |
| Intercultural Management and Communication (L0846) | Lecture | 2 | 2 |
| International Management (L0157) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Christian Lüthje |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Bachelor-level knowledge in marketing and (international) strategic management; basic understanding of market segmentation, modes of market entry, strategic management, pricing theory and marketing instruments.<br><br>The previous knowledge which is required for this module is taught by e-learning modules. Students receive access data and information regarding the online learning module after enrolment at TUHH. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students will develop a thorough understanding of the following:<br><br>• Selling to organizations and marketing strategies in B2B markets<br>• Relevant theories, methods and tools for operational B2B marketing<br>• Relevant theories for intercultural communication<br>• Theoretical knowledge of<br>  ◦ the importance of globalization for firms and the challenges facing companies in the context of their international operations;<br>  ◦ methods of measuring the internationalization degree of companies and the resulting practical implications;<br>  ◦ target market strategies, market entry strategies and foreign operation modes and allocation strategies;<br>  ◦ different types of international organizational structures (e.g. global organization, network organization, transnational organization);<br>  ◦ "culture" and its impact on human interaction;<br>  ◦ important aspects of (intercultural) communication issues.<br>  ◦ methods of analysis and assessment of market entry risks by applying modern theories such as the “Innovator’s Dilemma” framework;<br>  ◦ modes of cooperation such as prime contractor and consortium models and their industrial cooperation related advantages and disadvantages;<br>  ◦ special methods of assessment of specific country risks; |
| *Skills* | The students will be able to apply this knowledge to<br><br>• identify and systematically address relevant partners when selling to business organizations;<br>• place, price and communicate industrial products with the help state-of-the-art B2B marketing tools;<br>• define the specifics of global industries and respond to them deriving appropriate practical recommendations (global competitors, regional consumers, local and global suppliers, etc.);<br>• derive advantages and disadvantages of different target market, market entry, timing and allocation strategies;<br>• apply the theoretical knowledge to business cases or real examples (e.g. internationalization processes of well-known hotel chains or franchise companies, etc.);<br>• interpret symbols, rituals and gestures appropriately in an intercultural context.<br><br>**Based on these skills, the students will be able to**<br><br>• analyze market-entry options and market positioning in B2B markets;<br>• systematically analyze, work up and present information needed for making the decision for or against internationalization of company’s operations and regarding HOW, WHEN and WHAT;<br>• analyze and evaluate risks in the context of international business operations;<br>• decide which mode of market entry (e.g. franchising) yields most potential;<br>• make methodically based internationalization decisions as well as master the specifics of strategic management in an international context and apply concrete planning processes;<br>• develop strategies when approaching international client companies and manage relationships with complex client entities;<br>• develop sophisticated market-entry strategies and to position innovative industrial goods in global business-to-business markets;<br>• develop communication strategies in the domain of industrial goods, develop pricing plans by applying state-of-the-art tools like Vickrey-auctions to measure willingness-to-pay and methods such as tender-bidding models.<br>• solve complex operating planning tasks independently or in a team applying appropriate methods and comprehensibly present the results of their analysis;<br>• identify problems and resolve cultural issues in multi-cultural teams and in intercultural collaborations<br>• successfully manage cultural diversity. |
| **Personal Competence** | |
| *Social Competence* | The students will be able to |

| | |
|---|---|
| | • 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<br>• acquire knowledge in the specific context independently and to map this knowledge onto other new complex problem fields. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>Yes / 5 % / Excercises / |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | 3 written tests during the semester |
| **Assignment for the Following Curricula** | Global Innovation Management: Core Qualification: Compulsory<br>International Management and Engineering: Core Qualification: 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><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><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><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><br>• having fruitful professional discussions;<br>• presenting and defending the results of their work in groupwork;<br><br>**Self-reliance**<br><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, 3 rd 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 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>• 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 |

| Course L0157: International Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thomas Wrona |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Growing internationalization of companies and increased globalization require dealing with operations and specifics of international management as well as creating an understanding of intercultural differences. In order to help the students to understand these specifics and challenges accompanying international companies, the course will be divided in the following parts:<br>• Important Aspects in International Management<br>• Theories of Internationalization<br>• Specific characteristics of international companies and their strategies<br>• Organizational Structure and Leadership in international companies<br><br>During the course, the content will be covered from a theoretical as well as a practical point of view by using examples of different companies. In order to provide practical relevance to the course, a guest speaker from a well-known international company will be invited or alternatively a company visit will be organized as well as an analysis of a case study will take place. |
| **Literature** | 1. Course notes and materials provided before the lecture.<br>2. Selected books:<br>◦ Bartlett/Ghoshal (2002): Managing Across Borders, The Transnational Solution, 2nd edition, Boston<br>◦ Buckley, P.J./Ghauri, P.N. (1998), The Internationalization of the Firm, 2nd edition<br>◦ Czinkota, Ronkainen, Moffett, Marinova, Marinov (2009), International Business, Hoboken<br>◦ Dunning, J.H. (1993), The Globalization of Business: The Challenge of the 1990s, London<br>◦ Ghoshal, S. (1987), Global Strategy: An Organizing Framework, Strategic Management Journal, p. 425-440<br>◦ Praveen Parboteeah, K.,Cullen, J.B. (2011) , Strategic International Management, International 5th Edition<br>◦ Rugman, A.M./Collinson, S. (2012): International Business, 6th Edition, Essex 2012 |

## Module M1002: Production and Logistics Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Operative Production and Logistics Management (L1198) | Lecture | 2 | 2 |
| Strategic Production and Logistics Management (L1089) | Project-/problem-based Learning | 3 | 4 |

| | |
|---|---|
| **Module Responsible** | Prof. Wolfgang Kersten |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Introduction to Business and Management<br><br>The previous knowledge, that is necessary for the successful participation in this module is accessable via e-learning. Log-in and additional information will be distributed during the admission process. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students will be able<br>- to differentiate between strategic and operational production and logistics management,<br>- to describe the areas of production and logistics management,<br>- understand the difference between traditional and new concepts of production planning and control,<br>- to describe and explain the actual challenges and research areas of production and logistics management, esp. in an international context. |
| *Skills* | Based on the acquired knowledge students are capable of<br><br>- Applying methods of production and logistics management in an international context,<br>- Selecting sufficient methods of production and logistics management to solve practical problems,<br>- Selecting appropriate methods of production and logistics management also for non-standardized problems,<br>- Making a holistic assessment of areas of decision in production and logistics management and relevant influence factors,<br>- Design a production and logistics strategy and a global manufacturing footprint systematically. |
| **Personal Competence** | |
| *Social Competence* | After completion of the module students can<br>- lead discussions and team sessions,<br>- arrive at work results in groups and document them,<br>- develop joint solutions in mixed teams and present them to others,<br>- present solutions to specialists and develop ideas further. |
| *Autonomy* | After completion of the module students can<br><br>- assess possible consequences of their professional activity,<br><br>- define tasks independently, acquire the requisite knowledge and use suitable means of implementation,<br><br>- define and carry out research tasks bearing in mind possible societal consequences. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>Yes / 2.5 % / Excercises / Online-Modul<br>No / 15 % / Subject theoretical and practical work / PBL |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | International Management and Engineering: Core Qualification: Compulsory<br>Logistics, Infrastructure and Mobility: Core Qualification: Compulsory |

| Course L1198: Operative Production and Logistics Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thorsten Blecker |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Further knowledge of operational production management<br>• Traditional production planning and control concepts<br>• Recent production planning and control concepts<br>• Understanding and application of quantitative methods<br>• Further concepts regarding operational production management |
| **Literature** | Corsten, H.: Produktionswirtschaft: Einführung in das industrielle Produktionsmanagement, 12. Aufl., München 2009.<br>Dyckhoff, H./Spengler T.: Produktionswirtschaft: Eine Einführung, 3. Aufl., Berlin Heidelberg 2010.<br>Heizer, J./Render, B: Operations Management, 10. Auflage, Upper Saddle River 2011.<br>Kaluza, B./Blecker, Th. (Hrsg.): Produktions- und Logistikmanagement in Virtuellen Unternehmen und Unternehmensnetzwerken, Berlin et al. 2000.<br>Kaluza, B./Blecker, Th. (Hrsg.): Erfolgsfaktor Flexibilität. Strategien und Konzepte für wandlungsfähige Unternehmen, Berlin 2005.<br>Kurbel, K.: Produktionsplanung und -steuerung, 5., Aufl., München - Wien 2003.<br>Schweitzer, M.: Industriebetriebslehre, 2. Auflage, München 1994.<br>Thonemann, Ulrich (2005): Operations Management, 2. Aufl., München 2010.<br>Zahn, E./Schmid, U.: Produktionswirtschaft I: Grundlagen und operatives Produktionsmanagement, Stuttgart 1996<br>Zäpfel, G.: Grundzüge des Produktions- und Logistikmanagement, 2. Aufl., München - Wien 2001 |

| Course L1089: Strategic Production and Logistics Management | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Wolfgang Kersten |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Identification of the scope of production, operations and logistics management<br>• Understanding of actual challenges concerning production and logistics strategy<br>• Understanding operations as a competitive weapon<br>• Identification and design of the main elements of an operations strategy (level of vertical integration, technology strategy, location strategy, capacity strategy) of a company<br>• Understanding of international conditions for the development of a production and logistics strategy<br>• In depth discussion of different roles and design elements of a global manufacturing footprint<br>• Evaluation of operation strategies of different companies and industrial sectors<br>• In depth discussion of methods and concepts of production and logistics management<br>• In depth discussion of lean management: Main goals and measures of lean management and lean production concepts, impact of lean management on production and logistics strategies<br>• Analysis of the impact of digitalization on production and logistics strategies<br>• Presentation and discussion of current research topics in the field of production and logistics management<br>• Integration of Problem-Based-Learning sessions in order to enhance teamworking and problem solving skills as well as presentation skills |
| **Literature** | Arvis, J.-F. et al. (2018): Connecting to Compete - Trade Logistics in the Global Economy, Washington, DC, USA: The World Bank Group, Download: https://openknowledge.worldbank.org/handle/10986/29971<br><br>Corsten, H. /Gössinger, R. (2016): Produktionswirtschaft - Einführung in das industrielle Produktionsmanagement, 14. Auflage, Berlin/ Boston: De Gruyter/ Oldenbourg.<br><br>Heizer, J./ Render, B./ Munson, Ch. (2016): Operations Management (Global Edition), 12. Auflage, Pearson Education Ltd.: Harlow, England.<br><br>Kersten, W. et al. (2017): Chancen der digitalen Transformation. Trends und Strategien in Logistik und Supply Chain Management, Hamburg: DVV Media Group<br><br>Nyhuis, P./ Nickel, R./ Tullius, K. (2008): Globales Varianten Produktionssystem - Globalisierung mit System, Garbsen: Verlag PZH Produktionstechnisches Zentrum GmbH.<br><br>Porter, M. E. (2013): Wettbewerbsstrategie - Methoden zur Analyse von Branchen und Konkurrenten, 12. Auflage, Frankfurt/Main: CampusVerlag.<br><br>Schröder, M./ Wegner, K., Hrsg. (2019): Logistik im Wandel der Zeit - Von der Produktionssteuerung zu vernetzten Supply Chains, Wiesbaden: Springer Gabler<br><br>Slack, N./ Lewis, M. (2017): Operations Strategy, 5/e Pearson Education Ltd.: Harlow, England.<br><br>Swink, M./ Melnyk, S./ Cooper, M./ Hartley, J. (2011): Managing Operations across the Supply Chain, New York u.a.<br><br>Wortmann, J. C. (1992): Production management systems for one-of-a-kind products, Computers in Industry 19, S. 79-88<br><br>Womack, J./ Jones, D./ Roos, D. (1990): The Machine that changed the world; New York.<br><br>Zahn, E. /Schmid, U. (1996): Grundlagen und operatives Produktionsmanagement, Stuttgart: Lucius & Lucius<br><br>Zäpfel, G.(2000): Produktionswirtschaft: Strategisches Produktions-Management, 2. Aufl., München u.a. |

## 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.<br>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<br>• the most important principles of individual decision making in a national and international context<br>• different market structures<br>• types of market failure<br>• the functioning of a single economy (including money market, financial and goods markets, labor market)<br>• the difference between and the interdependence of short and long run equilibria<br>• the significance of expectations on the effects of economic policy<br>• the various links between economies<br>• 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<br>• the most important principles of individual decision making in a national and international context<br>• the market results of different market structures  and market failure<br>• the welfare effects of the market results<br>• expectations hypothesis<br>• the functioning of an economy (including money market, financial and goods markets, labor market)<br>• links between economies<br>• the effects of economic policies (trade, monetary, fiscal and exchange rate policies)<br>• to understand advanced economic models. |
| **Personal Competence** | |
| *Social Competence* | The students are able<br>• to anticipate expectations and decisions of individuals or groups of individuals. These may be inside or outside of the own firm.<br>• to take these decisions into account while deciding themselves<br>• 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<br>• to analyze empirical phenomena in single economies and the world economy and to reconile them with the studied theoretical concepts.<br>• 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** Yes · **Bonus** 5 % · **Form** Excercises · **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 2 hours |
| **Assignment for the Following Curricula** | International Management and Engineering: Core Qualification: Compulsory<br>Logistics, Infrastructure and Mobility: Core Qualification: Elective Compulsory<br>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 , 7th ed.  2010<br><br>Documents and notes handed out during the lecture. |

## Module M0995: Organization international companies and IT

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Logistics and Information Technology (L0065) | Lecture | 2 | 2 |
| Organization and Process Management (L1217) | Project-/problem-based Learning | 2 | 2 |
| Human Resource Management and Organization Design (L0108) | Lecture | 2 | 2 |

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|---|---|
| **Module Responsible** | Prof. Thorsten Blecker |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | 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* | Potentiale und Anwendungen neuer Informationstechnologien in der Logistik vor dem Hintergrund solider theoretischer Kenntnisse kritisch zu würdigen<br>praktische Fragestellungen auf Basis theoretischer Erkenntnisse zu diskutieren, bzw. einen Praxisbezugdurch Beispiele und Fallstudien herzustellen.<br>sich fachspezifische Kenntnisse aus der Literatur selbständig zu erarbeiten<br>Fallbeispiele und neue technische Entwicklungen ausder Praxis<br>Darstellung und vergleichende Analyse möglicher innerbetrieblicher und zwischenbetrieblicher Organisationsformen sowie Übertragung des theoretisch erworbenen Wissens auf Beispiele der internationalen Unternehmenspraxis; Diskussion ihrer Anwendbarkeit im Unternehmen sowie Erfolgsabwägungen |
| *Skills* | application of theoretical content, approaches and models of human resource management, organization and process management<br>• Analyze Workplace Design<br>• Monitor performance indicators, advantages and disadvantages of international cooperation<br>• Evaluation of empirical studies related to IT in the supply chain<br>• Assess the relevance of the information in the supply chain<br>• Analysis of the start-up phase of business and weighing of associated opportunities and risks deriving from common recommendations for action during the establishment phase<br>• Definition and assessment of possible legal forms; Transfer to national and international companies<br>• design and analysis of the process-oriented organizations targeting for efficient design of business processes<br>• weighing the pros and cons of process management; Development of approaches for optimization |
| **Personal Competence** | |
| *Social Competence* | • to develop joint problem solving proposals in the context of intercultural teamwork and to develop and process the results using modern presentation media;<br>• to conduct subject-specific and interdisciplinary discussions;<br>• presentations of work and results in German and English |
| *Autonomy* | • work independently on a subject and transfer the acquired knowledge to new problems. Discussion of applicability and success rates. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>Yes / 5 % / Excercises /<br>No / 10 % / Subject theoretical practical work / andim Rahmen der Lehrveranstaltung "Organisation und Prozessmanagement" |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | International Management and Engineering: Core Qualification: Compulsory<br>Logistics, Infrastructure and Mobility: Core Qualification: Elective Compulsory |

| Course L0065: Logistics and Information Technology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thorsten Blecker |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Basics of Logistics and Supply Chain Management<br>• Basis of Information Management<br>• Basics of Information Systems<br>• Empirical Studies Related to IT in Supply Chains<br>• Relevance of Information in the Supply Chain<br>• Logistics Information Systems<br>• Radio Frequency Identification (RFID)<br>• E-Logistics<br>• Electronic Sourcing<br>• E-Supply Chains<br>• Case Studies and New Technical Developments |
| **Literature** | • Kummer, S./Einbock, M., Westerheide, C.: RFID in der Logistik - Handbuch für die Praxis, Wien 2005.<br><br>Pepels, W. (Hsg.): E-Business-Anwendungen in der Betriebswirtschaft, Herne/Berlin 2002.<br><br>Reindl, M./Oberniedermaier, G.: eLogistics: Logistiksysteme und -prozesse im Internetzeitalter, München et al. 2002.<br><br>Schulte, C.: Logistik, 5. Auflage, München 2009<br><br>Wildemann, H.: Logistik Prozessmanagement, 4. Aufl., München 2009.<br><br>Wildemann H. (Hsg.): Supply Chain Management, München 2000. |

| Course L1217: Organization and Process Management | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Wolfgang Kersten |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Analyzing the set-up phase of new enterprises as well as associated risks and opportunities; joint development of recommendations for the set-up phase<br>• Definition and consideration of possible legal forms; application to national and international examples from the industry<br>• Analysis of process-oriented business structures for efficient configuration of operational workflows<br>• Description and comparative analysis of possible organizational forms and transfer into the praxis; opportunities to organize a company in practice; pros and cons of different organizational forms<br>• Analysis of possible cooperation forms between companies and applications in the industry<br>• Development of different participation types for employers and employees within the company; discussion and reflection of legal principles based on practical examples<br>• Description of the basics concerning corporate culture and knowledge management, as well as options for the practical implementation<br>• Weighing up the pros and cons of process management; development of optimization options<br>• Integration of problem based learning sessions to work on relevant case studies; joint development of possible problem solving solutions within intercultural teams; preparation of the results with modern presentation methods |
| **Literature** | • Becker, J. / Kugeler, M. / Rosemann, M. (2005): Prozessmanagement: Ein Leitfaden zur prozessorientierten Organisationsgestaltung, 5. Aufl., Berlin.<br>• Bullinger, H.-J. / Warnecke, H. J. (2003): Neue Organisationsformen im Unternehmen, 2. Auflage, Berlin.<br>• Eversheim, W. (2005): Integrierte Produkt- und Prozessgestaltung, Heidelberg.<br>• Gaitanides, M. (2007): Prozessorganisation: Entwicklung, Ansätze und Programme des Managements von Geschäftsprozessen, 2. Auflage, München.<br>• Heucher, M. et al. (2000): Planen, Gründen, Wachsen – Mit dem professionellen Businessplan zum Erfolg, 2. Auflage, Zürich.<br>• Hopfenbeck, W. (2002): Allgemeine Betriebswirtschafts- und Managementlehre – das Unternehmen im Spannungsfeld zwischen ökonomischen, sozialen und ökologischen Interessen, 14. Auflage, München.<br>• Porter, M. (1999): Wettbewerbsstrategie (competitive strategy): Methoden zur Analyse von Branchen und Konkurrenten, 10. Auflage, Frankfurt.<br>• Schreyögg, G. (2008): Organisation. Grundlagen moderner Organisationsgestaltung. 5. Auflage. GWV Fachverlag. Wiesbaden<br>• Wöhe, G. (2008): Einführung in die Allgemeine Betriebswirtschaftslehre, 23. Aufl., München. |

| 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 |
| **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. |

## Module M0916: Project Seminar IWI

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Project Seminar IWI (L1064) | Project Seminar | 3 | 6 |

| | |
|---|---|
| **Module Responsible** | Prof. Kathrin Fischer |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Prior knowledge in the relevant area from the relevant Management modules. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The knowledge and the skills which are gained in this module differ depending on the topic of the seminar. In all cases, in-depth knowledge of a certain scientific area and the respective skills are developed by the students, e.g. in-depth knowledge of complexity management in production, in-depth knowledge of the application of simulations in Controlling or in-depth knowledge of specific problems in Strategic Management or Marketing, and the respective skills, e.g. the ability to judge and select different approaches to certain strategic planning problems and to apply them successfully. Hence, the seminar is strongly research oriented. |
| *Skills* | Students are able to<br>• independently acquire the relevant knowledge to handle their project<br>• independently carry out a (pre-defined) complex research task and/or solve a complex problem<br>• select and use the relevant literature and critically evaluate it<br>• aggregate their knowledge and results and present it to others<br>• write a scientific report on the project / problem at hand, individually or in a team. |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>• work respectfully and successfully in a team, organize the team, and solve complex tasks in a team in a given timeframe<br>• analyse a problem in a team and develop a solution for the problem<br>• present the results of their work to specialists. |
| *Autonomy* | Students are able to<br>• define the scope of their project<br>• independently acquire relevant scientific knowledge<br>• independently carry out a (pre-defined) complex research task<br>• independently prepare a presentation of the relevant aspects of the project. |
| **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** | To be announced in seminar. |
| **Assignment for the Following Curricula** | International Management and Engineering: Core Qualification: Compulsory |

### Course L1064: Project Seminar IWI

| | |
|---|---|
| **Typ** | Project Seminar |
| **Hrs/wk** | 3 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 138, Study Time in Lecture 42 |
| **Lecturer** | Prof. Kathrin Fischer |
| **Language** | DE/EN |
| **Cycle** | WiSe/SoSe |
| **Content** | Contents differ, depending on the institute which organizes the respective seminar. Topics are always announced at the start of the term. |
| **Literature** | Wird je nach Thema angegeben; in der Regel handelt es sich um wissenschaftliche Fachartikel und Publikationen, vorwiegend in englischer Sprache. |

# Specialization I. Electives Management

## Module M0697: Management Control

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Management Control (L0496) | Lecture | 3 | 3 |
| Management Control (L0495) | Seminar | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Matthias Meyer |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge of financial and cost accounting |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can.... <br>• Discuss and distinguish between different concepts of controlling.<br>• Explain fundamental concepts of controlling.<br>• Outline and discuss important concepts, theories, and instruments that are of importance for controlling. |
| *Skills* | The students can.... <br>• Select suitable controlling instruments for dealing with business issues and deploy them by means of examples.<br>• Make recommendations for dealing with business issues with the aid of their controlling know-how and their methodical competence. |
| **Personal Competence** | |
| *Social Competence* | The students can.... <br>• Work together respectfully in teams, hold discussions and arrive at workable, sustainable results.<br>• Hold discussions on specific and overriding aspects of controlling. |
| *Autonomy* | The students are able... <br>• To acquire knowledge by themselves and to transfer the knowledge acquired to new problems.<br>• To argue the case for their findings (including in English). |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** No; **Bonus** 8.3 %; **Form** Excercises; **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory |

| Course L0496: Management Control | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Matthias Meyer |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Information provision: Ratios and ratio systems, balanced scorecard, reporting, information supply design<br>• Operative planning: Budgeting, operative production planning<br>• Operative controlling: Deviation analysis and forecasting<br>• Tactical planning: Quantitative and qualitative business planning<br>• Strategic planning: Portfolio analysis, SWOT analysis, resource-based view, experience curve concept<br>• Coordination: Economies of scope, value-oriented business ratios, transfer pricing, incentive systems, principal-agent theory<br>• Risk controlling: Value at risk, risk analysis, risk aggregation, risk management, risk control<br>• Project controlling |
| **Literature** | 1. Skript und Unterlagen, die zur Vorlesung und Übung herausgegeben werden.<br>2. Ausgewählte Bücher:<br>3. Balakrishnan, R./Sivaramakrishnan, K./Sprinkle, G. (2009): Managerial Accounting, Hoboken.<br>4. Ewert, R./Wagenhofer, A. (2008): Interne Unternehmensrechnung, 7. Aufl., Berlin.<br>5. Merchant, K./Van der Stede, W. (2012): Management Control Systems: Performance Measurement, Evaluation, and Incentives, London.<br>6. Weber, J./Schäffer, U. (2011): Einführung in das Controlling, 13. Aufl., Stuttgart. |

| Course L0495: Management Control | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Matthias Meyer |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | |
| **Literature** | 1. Skript und Aufgaben, die zur Vertiefung herausgegeben werden.<br>2. Weiterführende Literatur, die jeweils mit Blick auf die gesetzten Themenschwerpunkte spezifiziert wird |

## Module M0996: Supply Chain Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Supply Chain Management (L1218) | Project-/problem-based Learning | 3 | 4 |
| Value-Adding Networks (L1190) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Thorsten Blecker |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | no |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Current developments in international business activities such as outsourcing, offshoring, internationalization and globalization and emerging markets illustrated by examples from practice.<br>• Theoretical Approaches and methods in logistics and supply chain management and use in practice.<br>• to identify fields of decision in SCM .<br>• reasons for the formation of networks based on various theories from institutional economics (transaction cost theory, principal-agent theory, property-right theory) and the resource-based view.<br>• Selected approaches to explain the development of networks.<br>• to illustrate phases of network formation.<br>• to understand the functional mechanisms of inter-organizational and international network relationships.<br>• to explain and categorize relationships within networks.<br>• to categorize sourcing concepts and explain motives/ barriers or advantages and disadvantages.<br>• advantages and disadvantages of offshoring and outsourcing and to illustrate the distinction between the two terms .<br>• to state criteria/ factors/ parameters that influence production location decisions at the global level (total network costs).<br>• to explain methods for location finding/evaluation.<br>• to interpret phenotypes of production networks.<br>• recognize relationships between R & D and production and their locations and to describe coherent models.<br>• to solve sub-problems with the configuration of logistics networks (distribution and spare parts networks ) by the use of appropriate approaches.<br>• to categorise special waste logistics including their duties & objectives and to state and describe practical examples of good networking. |
| *Skills* | • to asses trends and challenges in national and international supply chains and logistics networks and their consequences for companies.<br>• to evaluate, anaylse and systematise networks and network relations based on the lecture.<br>• to anaylse partners and their suitability for co-operation in collaborations and cooperative relations.<br>• to select sourcing concepts for specific products / product components based on the lecture as well as advantages and disadvantages of each approach.<br>• to evaluate location decisions for production and R & D based on concepts.<br>• to recognize relationships between R & D and production as well as their locations and to evaluate the suitability of specific models for different situations.<br>• to transfer the analyzed concepts to international practices.<br>• to analyse and evaluate the product development processes.<br>• to anaylse concepts of Information and communication management in logistics.<br>• to design subcontracting, procurement, production and disposal as well as R & D networks to shape,<br>• to plan reorganise efficient and flow-oriented enterprise networks.<br>• to adopt methods of complexity management and risk management in logistics. |
| **Personal Competence** | |
| *Social Competence* | • to evaluate intercultural and international relationships based on discussed case studies.<br>• advance planning and design of network formation and their objectives based on content discussed in the lecture.<br>• definition of procurement strategies for individual parts using the gained knowledge of procurement networks.<br>• design of the procurement network (external/internal/modules etc.) based on the sourcing concepts and core competencies, as well as on the findings of the case studies.<br>• to make decision of location for production taking into account global contexts, evaluation methods and buying/selling markets, which were also discussed in the case studies and their dependence on R & D.<br>• Decision on R & D locations based on the insights gained from case studies / practical examples and the selection of an appropriate model. |
| *Autonomy* | After completing the module students are capable to work independently on the subject of Supply Chain Management and transfer the acquired knowledge to new problems. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** No; **Bonus** 15 %; **Form** Subject theoretical practical work; **Description** andim Rahmen der Lehrveranstaltung "Supply Chain Management" |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |

| | |
|---|---|
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory |

| **Course L1218: Supply Chain Management** | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Wolfgang Kersten |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Transmission of a profound understanding in logistics and supply chain management<br>• Transmission of theoretical approaches and methods in the field of logistics and supply chain management; transfer from theoretical concepts to business cases<br>• Identification of trends and challenges in national and international supply chains<br>• Elaboration and critical discussions concerning different supply chain configurations, as well as strategic supply chain approaches (e.g. push or pull-based strategies, efficiency vs. responsiveness)<br>• Elaboration of approaches and goals in the field of resource planning and supplier management<br>• Identification and analyzes of concepts in logistics management<br>• Implementation of the fields of purchasing, operations and sales into the business strategy<br>• Transmission of knowledge concerning demand management and distribution logistics<br>• Integration of a supply chain game based on the SCOR-model; preparation of the results with modern presentation methods |
| **Literature** | Bowersox, D. J., Closs, D. J. und Cooper, M. B. (2007): Supply chain logistics management, Boston, Mass. [u.a.], McGraw-Hill/Irwin.<br><br>Chopra, S. und Meindl, P. (2007): Supply chain management: strategy, planning, and operation, 3 rd edition, Upper Saddle River, NJ, Pearson/Prentice Hall.<br><br>Heizer, J. und Render, B. (2006): Principles of Operations Management. Prentice Hall.<br><br>Fisher, M. (1997): What is the right supply chain for your product?, Harvard Business Review, Vol. 75, No. pp., S. 105-116.<br><br>Kuhn, A. und Hellingrath, B. (2002): Supply Chain Management: optimierte Zusammenarbeit in der Wertschöpfungskette, Berlin [u.a.], Springer.<br><br>Larson, P., Poist, R., Halldórsson, Á. (2007): PERSPECTIVES ON LOGISTICS VS. SCM: A SURVEY OF SCM PROFESSIONALS, in: Journal of Business Logistics, Vol. 28, No. 1, 2007, S. 3ff.<br><br>Kummer, S., Hrsg. (2006): Grundzüge der Beschaffung, Produktion und Logistik, München: Pearson Studium.<br><br>Porter, M. (1986): Changing Patterns of International Competition, California Management Review, Vol. 28, No. 2, pp. 9-40.<br><br>Simchi-Levi, D., Kaminsky, P. und Simchi-Levi, E. (2008): Designing and managing the supply chain: concepts, strategies and case studies, 3. ed., McGraw-Hill.<br><br>Supply Chain Council (2010): Supply Chain Operations Reference (SCOR) model: Overview – Version 10.0, [online] :: http://supplychain.org/f/Web-Scor-Overview.pdf.<br><br>Swink, M., Melnyk, S. A., Cooper, M. B., Hartley, J. L. (2011): Managing Operations – Across the Supply Chain. McGraw-Hill/Irwin. |

| Course L1190: Value-Adding Networks | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Thorsten Blecker |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Introduction: Overview of current trade flows and development of global business cooperation<br>• Networks explanations using neo institutional approaches as a theoretical basis<br>• Networks organization and functioning<br>• Development stages of networks<br>• Presentation of different network types such as supplier, production, disposal and logistics network as well as their respective requirements, peculiarities and characteristics |
| **Literature** | • **Ballou, R.** Business Logistics/Supply Chain Management, Upper Saddle River 2004.<br>• **Bellmann, K.** (Hrsg.): Kooperations- und Netzwerkmanagement, Berlin 2001.<br>• **Bretzke, W.R.**: Logistische Netzwerke, Berlin Heidelberg 2008.<br>• **Blecker, Th. / Gemünden, H. G.** (Hrsg.): Wertschöpfungsnetzwerke, Berlin 2006.<br>• **Kaluza, B. / Blecker, Th.** (Hrsg.): Produktions- und Logistikmanagement in virtuellen Unternehmen und Unternehmensnetzwerken, Berlin et al. 2000.<br>• **Sydow, J. / Möllering**: Produktion in Netzwerken, Berlin 2009.<br>• **Willibald A. G.** (Hrsg.): Neue Wege in der Automobillogistik, Berlin Heidelberg 2007. |

## Module M0823: Project Management

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Selected Topics and Advanced Business Cases in Project Management (L0109) | Seminar | 2 | 2 |
| Project Management Methods (L0710) | Lecture | 1 | 2 |
| Strategies and Methods of Negotiating (L0761) | Project-/problem-based Learning | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Christian Ringle |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge of principles and concepts in business administration. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students will be familiar with...<br>• characteristics and critical success factors of projects;<br>• typical phases in projects, corresponding tasks and challenges;<br>• advanced methods and tools which can be applied in special phases of a project (such as cost-benefit analyses, scheduling techniques, business process modeling techniques, change management approaches);<br>• important soft factors influencing a project’s success such as cultural aspects, team dynamics and leadership approaches;<br>• different project management approaches (classic vs. agile project management);<br>• practical cases of international project management;<br>• strategies and advanced methods of negotiation including game theory. |
| *Skills* | Students will be able to...<br>• conduct stakeholder and industry analyses;<br>• critically analyze industries and multinational firms in terms of, e.g., their competitive situation, their strengths and weaknesses;<br>• systematically implement project management techniques to international projects (e.g., plan international projects, deal with uncertainty, establish, harmonize and track quality, time and cost objectives);<br>• apply project management techniques to complex business cases (e.g., optimize the target setting process, develop work breakdown structures, develop schedules and action plans, monitor project progress, manage risk throughout the project, and do the project controlling);<br>• apply strategies and methods of negotiation to complex business cases;<br>• internalize the components of an effective negotiation and practice their use;<br>• successfully apply strategies and methods of negotiation in business practice in an international context (e.g., expose and overcome typical barriers to an agreement such as lack of trust, deal with typical hardball tactics such as good cop/bad cop, lowball/highball, intimidation, and avoid cognitive traps such as unchecked emotions, overconfidence);<br>• work target-oriented on exercises to solve case studies;<br>• appropriately present results of their work to others, both in terms of reports and oral presentations. |
| **Personal Competence** | |
| *Social Competence* | The students will be able to...<br>• have fruitful group discussions;<br>• present their results in written form and by oral presentations;<br>• collaborate respectfully in a multicultural team;<br>• be reflective on their own behavior in negotiations. |
| *Autonomy* | The students will be able to acquire further relevant information independently, critically evaluate this information and improve or adapt management techniques to new situations in international business practice. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>Yes / 33 % / Subject theoretical and practical work<br>Yes / 33 % / Subject theoretical and practical work |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 minutes |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory |

| Course L0109: Selected Topics and Advanced Business Cases in Project Management | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Ringle |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | This seminar addresses current topics of strategic relevance to multinational firms and provides students with the opportunity to enhance the theoretical capabilities as well as to apply their knowledge to complex case studies taken from business practice. Thereby, the students will also strengthen their soft skills (e.g., team work, presentation skills) which are required for all kinds of project related jobs in an international business context. The general topic of the seminar and the detailed case studies will be announced in each semester. Cases include the following general topics:<br>• Different approaches of project management (classic vs. agile project management);<br>• Evaluating industries and the business situation of multinational firms (e.g., identify strengths and weaknesses, analyze and forecast costs and benefits);<br>• Developing and applying international management strategies;<br>• Managing business processes (incl. business process modeling and re-engineering);<br>• Managing international projects;<br>• Managing change in a multinational firm. |
| **Literature** | Information on the appropriate literature depends on the topics and will be updated each semester. Literature may include two textbooks (in addition to the ones below) that address the theoretical underpinnings of the general topic, journal articles, an introduction on how to develop case study solutions, and the case study text. General textbooks referred to are:<br>• Dess, G. G. / Lumpkin, G. T. / Eisner, A. B. / Kim, Bongjin: Strategic Management, 6e, New York: McGraw-Hill/Irwin, 2012.<br>• Jones, G. R. / Hill, C. W. L. (2010): Theory of Strategic Management with Cases, 9e, South-Western: Cengage Learning.<br>• Larson, E. W. / Gray, C. (2017): Project Management, 7e, Boston: McGraw-Hill.<br>• Mantel, S. J. / Meredith, J. R. / Shafer, S. M. / Sutton, M. M. (2016): Project Management in Practice, 6e, New Jersey: Wiley. |

| Course L0710: Project Management Methods | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **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 L0761: Strategies and Methods of Negotiating | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Lüthje |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | **General description of course content and course goals**<br>The purpose of the present course is to understand the theory and processes of negotiation as practiced in a variety of settings such as industrial marketing relations. A basic premise is that while students need analytical skills in order to develop optimal solutions, a broad array of negotiation skills is needed in order for these solutions to be accepted and implemented. Yet, even though we often negotiate, many students have limited knowledge about the strategies for and psychology of effective negotiations, which is going to be an important factor in their future careers. The course will highlight the components of an effective negotiation and teach students to analyze their own behavior in negotiations.<br>The course structure is experiential and problem-based, combining lectures, class discussion, assigned readings, media |

presentations, and the practice of negotiations. Through participation in problem-based negotiation exercises, students will have the opportunity to practice their communication and persuasion skills and to experiment with a variety of negotiating strategies and tactics. Through analysis of case studies, media, and discussion of readings on negotiation concepts and tactics, students will apply the lessons learned to ongoing, real-world negotiations.

**Summarizing the most important contents**

The students will find answers to the following fundamental questions of negotiation theory and practice:

- How do negotiations influence everyday life and business processes?
- What are key features of negotiations?
- What are different forms of negotiations? What kinds of negotiation can be distinguished?
- Which theoretical approaches to a theory of negotiation can be distinguished?
- How can game theory be applied to negotiation?
- What makes an effective negotiator?
- Which factors should be considered when planning negotiations?
- What steps must be followed to reach a deal?
- Are there specific negotiation tactics?
- What are the typical barriers to an agreement and how to deal with them?
- What are possible cognitive (mental) errors and how to correct them?

**Professional Competence**

**Knowledge**

Students can...

- explain the theory and underlying processes of negotiation as practiced in a variety of daily-life and business settings such as in industrial marketing relations.
- explain strategies for and psychology of effective negotiations in daily-life and business situations (e.g. the steps that must be followed to reach a deal, mental errors, and the typical barriers to an agreement).
- give an overview of the basics of game theory, (behavioral) decision theory, and negotiation analysis (e.g. distributive and integrative situations, core strategies and tactics, key concepts, stages, team building and roles, anchoring and first offers, multi-phase negotiations).

**Skills**

Students are capable of...

- simultaneously considering multiple factors in negotiation situations and taking reasoned actions when preparing and conducting negotiations.
- Analyzing and handling the key challenges of uncertainty, risk, intercultural differences, and time pressure in realistic negotiation situations.
- assessing the typical barriers to an agreement (e.g. lack of trust), dealing with hardball tactics (e.g. good cop, bad cop; lowball, highball; intimidation), and avoiding cognitive traps (e.g. unchecked emotions, overconfidence).
- reflecting on their decision-making in uncertain negotiation situations and derive actions for future decisions.

**Personal Competence**

**Social Competence**

Students can...

- provide appropriate feedback and handle feedback on their own performance constructively.
- enter into a dialogue with formerly unknown fellow students, participate in discussions, and present well-grounded arguments.
- constructively interact with their team members and lead team sessions and group work processes
- develop joint solutions in mixed teams and present them to others in real-world negotiation situations

**Self-Reliance**

Students are able to...

- assess possible consequences of their own negotiation behavior
- define own positions and tasks in the negotiation preparation process.
- justify and make elaborated decisions in authentic negotiation situations.

**Literature**

R.J. Lewicki / B. Barry / D.M. Saunders: Negotiation. Sixth Edition, McGraw-Hill, Boston, 2010.

H. Raiffa: Negotiation analysis. Belknap Press of Harvard Univ. Press, Cambridge, Mass, 2007.

R. Fisher / W. Ury: Getting to yes. Third edition. Penguin, New York, 2011.

M. Voeth / U. Herbst: Verhandlungsmanagement: Planung, Steuerung und Analyse. Schäffer-Poeschel, Stuttgart, 2009.

## 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. 4$^{th}$ 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 M0866: EIP and Productivity Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Elements of Integrated Production Systems (L0927) | Project-/problem-based Learning | 2 | 3 |
| Productivity Management (L0928) | Project-/problem-based Learning | 2 | 2 |
| Productivity Management (L0931) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Hermann Lödding |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic lecture in Production Organization or Production Management |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | not available |
| *Skills* | not available |
| **Personal Competence** | |
| *Social Competence* | not available |
| *Autonomy* | Students are able to define research-related tasks, to acquire the requisite knowledge and to apply it to a problem. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes · **Bonus** None · **Form** Excercises · **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 Minuten |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory |

### Course L0927: Elements of Integrated Production Systems

| | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Hermann Lödding |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | not available |
| **Literature** | Harris, R.; Harris, C.; Wilson, E.: Making Materials Flow, Lean Enterprise Institute, Cambridge, 2003.<br>Ohno, T.: Das Toyota-Produktionssystem, Campus-Verlag, Frankfurt et al, 1993.<br>Rother, M.: Die Kata des Weltmarktführers. Toyotas Erfolgsmethoden, Campus-Verlag, Frankfurt et al, 2009.<br>Rother, M.; Shook, J.: Sehen lernen: Mit Wertstromdesign die Wertschöpfung erhöhen und Verschwendung beseitigen, Lean Management Institut, Aachen, 2006.<br>Rother, M.; Harris, R.: Creating Continuous Flow, Lean Enterprise Institute, Brookline, 2001.<br>Shingo, S.: A Revolution in Manufacturing. The SMED System, Productivity Press, 2006.<br>Womack, J. P. et al: Die zweite Revolution in der Autoindustrie, Frankfurt/New York, Campus Verlag, 1992. |

| Course L0928: Productivity Management | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Hermann Lödding |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Principles of productivity management<br>• Shop floor management and standardisation<br>• Takt analysis and design of manual operations<br>• Maintenance Principles<br>• Total Productive Maintenance (TPM)<br>• Optimisation of set-up operations<br>• Analysis of interlinked production systems |
| **Literature** | Bokranz, R.; Landau, K.:Produktivitätsmanagement von Arbeitssystemen. Schäffer-Poeschel, Stuttgart, 2006.<br>Takeda, H.: Das synchrone Produktionssystem: Just-in-Time für das ganze Unternehmen. 5. Aufl., mi-Wirtschaftsbuch, FinanzBuch Verlag, München, 2006.<br>Nakajima, S.: Management der Produktionseinrichtungen (Total Productive Maintenance). Campus Verlag, New York, 1995.<br>Shingo, S.: A Revolution in Manufacturing: The SMED System. Productivity, Inc., 1985 |

| Course L0931: Productivity Management | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Hermann Lödding |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## 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 M0558: Operations Research

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Operations Research (L0155) | Lecture | 2 | 2 |
| Operations Research - Seminar (L0156) | Seminar | 2 | 3 |
| Project Operations Research (L1793) | Project-/problem-based Learning | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Kathrin Fischer |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Knowledge from the module "Quantitative Methods": Linear Programming, Network Optimization and basics of Integer Programming. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students have an in-depth knowledge of the following areas: They are able to<br>• explain complex quantitative models for applications, e.g. production models with integrated inventory holding over time, portfolio models, revenue management models<br>• Discuss advanced topics in linear programming, e.g, duality theory and its application, special structures as upper/lower bounds for variables; revised simplex method etc.<br>• Analyze problems with multiple objectives and under uncertainty, i.e. the adaption of linear programming models to realistic applications as e.g. international humanitarian logistics problems (distribution of relief goods);<br>• Discuss advanced topics in integer programming: complex problems, e.g. from vehicle routing, and logical constraints; advanced solutions procedures as branch and bound, cutting-plane procedures etc.<br>• Examine dynamic and non-linear programming problems and applications in Management;<br>• Solve OR problems using appropriate software;<br>• Understand and explain OR reserach projects they learn about in the course. |
| *Skills* | Students have in-depth abilities in the following areas: They are able to<br>• formulate complex quantitative models for applications, e.g. production models with integrated inventory holding over time, portfolio models, revenue management models<br>• Apply duality theory in linear programming and analyze special structures as upper/lower bounds for variables; use the revised simplex method etc.<br>• Analyze problems with multiple objectives and under uncertainty, i.e. the adaption of linear programming models to realistic applications<br>• Set up advanced models in integer programming and solve them, e.g. problems from vehicle routing, or logical constraints<br>• Analyze dynamic and non-linear programming problems and applications in Management<br>• to understand a specified planning problem of OR research, to implement a solution and to document and explain their approach in a concise way. |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>• work successfully in a team, organize the team, and solve complex tasks in a team in a given time frame<br>• give structured feedback, following feedback rules, and also accept deeback from their fellow students<br>• lead discussions on problems from the field of OR<br>• present the results of their work to specialists. |
| *Autonomy* | Students are able to<br>• independently acquire relevant scientific knowledge from the literature<br>• independently carry out a (pre-defined) complex research task<br>• aggregate their knowledge and results and present it to others<br>• apply their knowledge and experience also to new problems and unknown situations. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes · **Bonus** 10 % · **Form** Group discussion · **Description** |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | To be announced in Lecture |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Core Qualification: Elective Compulsory |

| Course L0155: Operations Research | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kathrin Fischer |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Complex quantitative models for applications, e.g. production models with integrated inventory holding over time, portfolio models, revenue management models<br>• Advanced topics in linear programming, e.g, duality theory and its application, special structures as upper/lower bounds for variables; revised simplex method etc.<br>• Problems with multiple objectives and under uncertainty: adaption of linear programming models to realistic applications<br>• Topics from current OR research, e.g. from the field of humanitarian logistics and revenue management<br>• Advanced topics in integer programming: Modelling complex problems, e.g. from vehicle routing, and logical constraints; advanced solutions procedures as branch and bound, cutting-plane procedures etc.<br>• Dynamic and non-linear programming and its applications in Management<br>• Applications of models and methods in the area of supply chain management and logistics, e.g. in location planning etc. |
| **Literature** | Bücher:<br><br>Albright, C., Winston, W.: Management Science Modeling. Revised Third Edition, South-Western 2009.<br><br>Eiselt, H.A., Sandblom, C.-L.: Linear Programming and its Applications, Springer 2007.<br><br>Eiselt, H.A., Sandblom, C.-L.: Integer Programming and Network Models, Springer 2000.<br><br>Eiselt, H.A., Sandblom, C.-L.: Decision Analysis, Location Models, and Scheduling Problems, Springer 2004.<br><br>Suhl, L., Mellouli, T.: Optimierungssysteme. Springer, Berlin et al., 2. Auflage, 2009.<br><br>Williams, H.P.: Model Building in Mathematical Programming. 5th edition, Wiley & Sons, 2013.<br><br>Winston, W., Venkataramanan, M.: Mathematical Programming. Operations Research, Volume 1, 4th Edition, Thomson, London et al. 2003.<br><br>Sowie ein Skript, das zur Vorlesung herausgegeben wird. |

| Course L0156: Operations Research - Seminar | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kathrin Fischer |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Special topics from different areas of the lecture are discussed in the seminar.<br><br>Students are required to use current publications from highly esteemed journals in their assignment and to write an essay on a relevant OR topic. Moreover, they have to prepare and give  a talk on that topic.<br><br>The seminar is research-oriented and focuses on relevant research topics from the field. Students get a first-hand experience in carrying out a research project in a well-defined, limited area of OR.<br><br>There is a limitation of  the number of seminar participants (36 students). If necessary, selection of participants will be based on the results in the Quantitative Methods module which is a prerequisite for this course. |
| **Literature** | Fachartikel (Journal Papers), die zu Beginn des Seminars bekanntgegeben werden. |

| Course L1793: Project Operations Research | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Kathrin Fischer |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | In this course, students develop a computer-based realization for a business application problem in a team of students.<br><br>In particular, they are required to carry out the following steps:<br><br>• Modeling the planning situation<br>• Implementation and documentation<br>• Generation of appropriate test data<br>• Testing the implementation, sensitivity analyses etc.<br>• Documentation of results and critical evaluation |
| **Literature** | Siehe Vorlesung Operations Research |

## 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

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| | 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: Yes; Bonus: 20 %; Form: Presentation; Description: |
| **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><br>Bernardin, H.J. (2006): Human Resource Management: An Experiential Approach, 4e, New York: McGraw-Hill.<br><br>Cascio, W. (2015): Managing Human Resources: Productivity, Quality of Work Life, Profits, revised edition, New York: McGraw-Hill.<br><br>French, W./Bell, C.H./Zawacki, R.A. (2004): Organization Development and Transformation: Managing Effective Change, 6e, Chicago: McGraw-Hill.<br><br>Hitt, M.A./Ireland, R.D./Hoskisson, R.E. (2014): Strategic Management: Competitiveness and Globalization, 11e, Ohio: Cengage Learning.<br><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><br>Bernardin, H.J. (2006): Human Resource Management: An Experiential Approach, 4e, New York: McGraw-Hill.<br><br>Cascio, W. (2015): Managing Human Resources: Productivity, Quality of Work Life, Profits, revised edition, New York: McGraw-Hill.<br><br>French, W./Bell, C.H./Zawacki, R.A. (2004): Organization Development and Transformation: Managing Effective Change, 6e, Chicago: McGraw-Hill.<br><br>Hitt, M.A./Ireland, R.D./Hoskisson, R.E. (2014): Strategic Management: Competitiveness and Globalization, 11e, Ohio: Cengage Learning.<br><br>Lynch, R. (2015): Strategic Management, 7e, Harlow: Prentice Hall. |

## Module M0559: Strategic Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Strategic Management (L0158) | Lecture | 4 | 6 |

| | |
|---|---|
| **Module Responsible** | Prof. Thomas Wrona |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic principles in International and Intercultural Management |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students will accumulate extensive knowledge about different aspects of strategic management after having participated in this module. Apart from strategic planning, students will be able to discern different contingency factors in strategic decision making and apply various strategies accordingly.<br><br>Students will gain competences in the following areas:<br>• The historical and theoretical development of strategic management<br>• Different forms of strategy formation<br>• Content and process view of strategic management<br>• Formulation and implementation of strategic options<br>• Management systems and their influence on strategies<br>• The origins of competitive advantage |
| *Skills* | • Students are able to analyze and interpret external and internal information in the context of strategic choice<br>• Students are able to differentiate environmental contingencies and assess risk potentials<br>• Students are able to evaluate the attractiveness of different industries<br>• Students are able to evaluate the pros and cons of strategic options and adequately select strategies during implementation<br>• In essence, students are able to conceptually and theoretically “design” strategic decision processes and considers industry and corporate peculiarities during strategic planning<br><br>Those skills refer to competences in information seeking and analysis, the consolidation of data and their presentation in teams. These skills will be continuously shaped...<br>• During case studies and strategic role plays, where students identify, develop and implement solutions for strategic problems<br>• During complex data analyses, which are performed in groups and discussed in class<br>• By making educated guesses about (yet unknown) corporate phenomena and decision makers attitudes, which are based on prior theoretical knowledge |
| **Personal Competence** | |
| *Social Competence* | After attending the module students will be able...<br>• To interact  and share own thoughts with group members during case study sessions or strategic role plays<br>• To lead and take part in strategy-related discussions<br>• To present results, both in written and verbal form |
| *Autonomy* | After attending the module students will be able...<br>• To accumulate knowledge about specified strategic problems and transfer it to other related areas of interest<br>• To identify related literature and integrate relevant findings during problem solution<br>• To present existing and new knowledge about strategic phenomena in own conceptual ways |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory**: No; **Bonus**: 20 %; **Form**: Subject theoretical and practical work; **Description**: |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory |

| Course L0158: Strategic Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 4 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Lecturer** | Prof. Thomas Wrona |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction - Basic concepts and objects within the area of strategic management<br>• Objectives, corporate strategies, mission statements and management systems as an object of strategic management<br>• Theoretical perspectives of strategic management<br>• Analysis and design of selected strategies<br>• Strategic (planning) processes<br>• Integrative application of knowledge based on a number of selected case studies<br><br>Theoretical, conceptual parts are devoted to the processing and discussion of theoretical contributions from current management research, which are practically applied in case studies and simulations. |
| **Literature** | Bamberger, I./Wrona, T. (2012): Strategische Unternehmensführung. Strategien - Systeme - Prozesse,<br>2. überarbeitete und erweiterte Auflage, München 2012<br><br>Bamberger, I./Wrona, T. (2012): Strategische Unternehmensberatung, 6. erweiterte Auflage, Wiesbaden 2012<br><br>Bamberger, I./Wrona, T. (1996): Der Ressourcenansatz und seine Bedeutung für die Strategische Unternehmensführung, in: Schmalenbachs Zeitschrift für betriebswirtschaftliche Forschung (zfbf), 2/1996, S. 130-153<br><br>Bowman, E.H./Singh, H./Thomas, H. (2006): The domain of strategic management: History and evolution, in: Pettigrew, A./Thomas, H./Whittington, R. (Hrsg.): Handbook of strategy and management, London u.a. 2006, S. 31-54<br><br>Johnson, G./Whittington, R./Scholes, K./Angwin, D./Regnér, D. (2017): Exploring strategy. Text and Cases, 11. Aufl., Harlow 2017<br><br>Kreikebaum, H./Gilbert, D. U./Behnam, M. (2018): Strategisches Management, Stuttgart.<br><br>Mintzberg, H./Ahlstrand, B./Lampel, J. (2002): Strategy Safari, New York 2002 (in deutscherSprache: Dies. (2012): Strategy Safari: Der Wegweiser durch den Dschungel des strategischen Managements, 2. Aufl., München 2012)<br><br>Porter, M. E. (2013): Wettbewerbsstrategie. Methoden zur Analyse von Branchen und Konkurrenten, 12. Aufl., Frankfurt 2013<br><br>zu Knyphausen-Aufseß, D. (2012): Theoretische Perspektiven des strategischen Managements, in: Welge, M.K./Al-Laham, A./Kajüter, P. (Hrsg.): Praxis des strategischen Managements, Wiesbaden 2012, S. 39-70<br><br>Skripte und Textdokumente, die während der Vorlesung herausgegeben werden: |

## 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>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 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 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". |

## Module M0994: Information Technology in Logistics

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Informationtechnology in Logsitics (L1197) | Practical Course | 6 | 6 |

| | |
|---|---|
| **Module Responsible** | Prof. Thorsten Blecker |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Knowledge from the module "Production and Logistics Management";<br>Interest in new technologies and their application in logistics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • on the relationship between logistics and IT, and representation and describtion in depth;<br>• information systems and information management, and the application of information systems and information management to logistical issues;<br>• using information technologies that are currently used in logistics, such as RFID, e-logistics and electronic sourcing. |
| *Skills* | • to assess the use of information technology in logistics issues and to implement appropriate technologies;<br>• to be able to deal critically with the current developments in IT and logistics and to assess them critically;<br>• analyse in depth relevant issues arising from the thematic field of "IT in Logistics" at a scientific level;<br>• to independently work on current topics from the field of "IT in Logistics";<br>• analyse the relationship between logistics and IT;<br>• implementing information technology in logistics successfully<br>• to transfer the theoretical knowledge of information technologies to real situations and to give recommendations of action for solving new tasks;<br>• to solve logistical problems using information technology |
| **Personal Competence** | |
| *Social Competence* | • to conduct subject-specific and interdisciplinary discussions;<br>• oral and written presentation of results<br>• respectful team work |
| *Autonomy* | • work independently on a subject and transfer the acquired knowledge to new problems. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | - |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory |

### Course L1197: Informationtechnology in Logsitics

| | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 6 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Lecturer** | Prof. Thorsten Blecker |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • In the beginning the students get insight of the functionality of a service-oriented architecture.<br>• Then the students will get a logistic problem to solve in small groups.<br>• The elaborations result shall be one or more programmed services/module that together with the other groups result completes a total application. |
| **Literature** | Skripte und Textdokumente, die während der Vorlesung herausgegeben werden |

## 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** / **Bonus** / **Form** / **Description**<br>Yes / 20 % / Group discussion / |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | Presentations and case study work |
| **Assignment for the Following Curricula** | Global Innovation Management: Core Qualification: Elective Compulsory<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 M1003: Management Control Systems for Operations

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Management Control Systems for Operations (L1219) | Project-/problem-based Learning | 3 | 4 |
| Management Control Systems for Operations (L1224) | Recitation Section (small) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Wolfgang Kersten |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Introduction to Business and Management |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students have acquired in depth knowledge in the following areas and can<br>• explain the function and the requirements of management control systems,<br>• explain the targets and the tasks of production and supply chain comtrolling,<br>• understand management control systems for production in an international context,<br>• explain the major aspects of investment planning and control,<br>• explain the major aspects of cost management,<br>• explain and understand the procedures of budgeting,<br>• present and give a detailed explanation of methods and tools of management control systems for production and supply chains,<br>• describe opportunities and risks of digitalization for the design of management control systems for production and supply chains,<br>• give an overview of relevant research topics for management control systems for production and supply chains. |
| *Skills* | Based on the acquired knowledge students are capable of<br>- Applying methods of managerial accounting in production and logistics in an international context,<br>- Selecting sufficient methods of managerial accounting in production and logistics to solve practical problems,<br>- Selecting appropriate methods of managerial accounting in production and logistics also for non-standardized problems,<br>- Making a holistic assessment of areas of decision in management control systems for production and logistics and relevant influence factors. |
| **Personal Competence** | |
| *Social Competence* | After completion of the module students can<br>- lead discussions and team sessions,<br>- arrive at work results in groups and document them,<br>- develop joint solutions in mixed teams and present them to others,<br>- present solutions to specialists and develop ideas further. |
| *Autonomy* | After completion of the module students can<br>- assess possible consequences of their professional activity,<br>- define tasks independently, acquire the requisite knowledge and use suitable means of implementation,<br>- define and carry out research tasks bearing in mind possible societal consequences. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes; **Bonus** 20 %; **Form** Subject theoretical and practical work; **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Management and Controlling: Elective Compulsory<br>International Management and Engineering: Specialisation I. Electives Management: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory |

| Course L1219: Management Control Systems for Operations | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Wolfgang Kersten |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Identification of missions and changing requirements on controlling<br>• Differentiating managerial accounting, production management, logistics and supply chain controlling<br>• Considering global dispersed supply chain networks in production management and supply chain controlling<br>• Analyzing investment projects and resulting effects (investment control, risk management in investment)<br>• In depth knowledge in planning, realizing and controlling investments<br>• Developing characteristics of differentiation for cost and activity accounting (aim, purpose, opportunities in structuring etc.)<br>• In depth knowledge in cost management (cost types and units)<br>• Budgeting in practice; Analysis of existing methods<br>• Development of an approach in activity based costing<br>• Application of target costing<br>• Knowing the importance and method of life cycle costing<br>• Applying performance figures in production and logistics<br>• Discussion of opportunities and risks of digitalization for the design of management control systems for production and supply chains<br>• Developing recommendations for problem solving by using research oriented problem based learning sessions for relevant actual topics and cases; thereby preparing and presenting results in intercultural teams |
| **Literature** | Altrogge, G. (1996): Investition, 4. Aufl., Oldenbourg, München<br><br>Arvis, J.-F. et al. (2018): Connecting to Compete - Trade Logistics in the Global Economy, The World Bank Group, Washington, DC, USA; Download: https://openknowledge.worldbank.org/handle/10986/29971<br><br>Betge, P. (2000): Investitionsplanung: Methoden, Modelle, Anwendungen, 4. Aufl., Vahlen, München.<br><br>Christopher, M. (2005): Logistics and Supply Chain Management, 3. Aufl., Pearson Education, Edinburgh.<br><br>Eversheim, W., Schuh, G. (2000): Produktion und Management. Betriebshütte: 2 Bde., 7. Aufl., Springer Verlag, Berlin.<br><br>Günther, H.-O., Tempelmeier, H. (2005): Produktion und Logistik, 6. Aufl., Springer Verlag, Berlin.<br><br>Hahn, D. Horváth, P., Frese, E. (2000): Operatives und strategisches Controlling, in: Eversheim, W., Schuh, G. (Hrsg.): Produktion und Management. Betriebshütte: 2 Bde. Springer Verlag, Berlin.<br><br>Hansmann, K.-W. (1987): Industriebetriebslehre, 2. Aufl., Oldenbourg, München.<br><br>Hoitsch, H.-J. (1993): Produktionswirtschaft: Grundlagen einer industriellen Betriebswirtschaftslehre, 2. Aufl., Vahlen, München.<br><br>Horváth, P./ Gleich, R./ Seiter, M. (2015): Controlling, 13. Aufl., Vahlen, München.<br><br>Kersten, W. et al. (2017): Chancen der digitalen Transformation. Trends und Strategien in Logistik und Supply Chain Management, DVV Media Group, Hamburg.<br><br>Kruschwitz, L. (2009): Investitionsrechnung, 12. Aufl., Oldenbourg, München.<br><br>Martinich, J. S. (1997): Production and operations management: an applied modern approach. Wiley.<br><br>Preißler, P. R. (2000): Controlling. 12. Aufl., Oldenbourg Wissenschaftsverlag, München.<br><br>Weber, J./ Wallenburg, C. M. (2010): Logistik- und Supply Chain Controlling, 6. Auflage, Schaeffer Poeschel Verlag, Stuttgart.<br><br>Wildemann, H. (1987): Strategische Investitionsplanung, Methoden zur Bewertung neuer Produktionstechnologien, Gabler, Wiesbaden.<br><br>Wildemann, H. (2001): Produktionscontrolling: Systemorientiertes Controlling schlanker Produktionsstrukturen, 4. Aufl. TCW, München. |

| Course L1224: Management Control Systems for Operations | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Wolfgang Kersten |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

# Specialization II. Civil Engineering

## Module M0998: Statics and Dynamics of Structures

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Structural Dynamics (L1202) | Lecture | 2 | 2 |
| Structural Dynamics (L1203) | Recitation Section (large) | 2 | 2 |
| Fracture mechanics and fatigue in steel structures (L0564) | Lecture | 1 | 1 |
| Fracture Mechanics and Fatigue (L0565) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Uwe Starossek |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Knowledge of linear structural analysis of statically determinate and indeterminate structures; Mechanics I/II, Mathematics I/II, Differential equations I |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After successful completion of this module, the student can explain the basic aspects of dynamic effects on structures and the respective methods. |
| *Skills* | After successful completion of this module, the students will be able to predict the response of material and structures to dynamics loading using the appropriate computational approaches and methods. |
| **Personal Competence** | |
| *Social Competence* | Students can<br>• participate in subject-specific and interdisciplinary discussions,<br>• defend their own work results in front of others<br>• promote the scientific development of colleagues<br>• Furthermore, they can give and accept professional constructive criticism |
| *Autonomy* | Students are able to gain knowledge of the subject area from given and other sources and apply it to new problems. Furthermore, they are able to structure the solution process for problems in the area of Structural Analysis. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 150 min |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Structural Engineering: Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory |

| Course L1202: Structural Dynamics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Uwe Starossek |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Single-degree-of-freedom systems: undamped and damped vibration, free vibration, forced vibrations due to harmonic, periodical or arbitrary loading, natural frequency, damping<br>• vibration isolation<br>• solution in the frequency-domain (Fourier transformation), solution in the time-domain<br>• multi-degree-of-freedom systems: continuous or discrete systems, modelling with finite elements, generalisation<br>• modal analysis<br>• power iteration according to v.Mises<br>• earthquake loading: seismological basics, response spectrum method<br>• wind-induced vibrations: engineering meteorology, aerodynamic, classification of excitation mechanisms<br><br>progressive collapse |
| **Literature** | Clough, R.W., Penzien, J.: Dynamics of Structures. 2. Aufl., McGraw-Hill, New York, 1993. |

| Course L1203: Structural Dynamics | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Uwe Starossek |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0564: Fracture mechanics and fatigue in steel structures | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Ingo Hadrych |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • basics of fatigue stress and fatigue resistance and determination of fatigue strength,<br>• determination anduse of S-N-curves and classification of notch effects,<br>• set up of determination of fatigue strength under dynamic load using the accumulation formula by Palmgren-Miner,<br>• set up of determination of fatigue strength in different examples,<br>• basics of construction and design regarding the problem of material fatigue,<br>• basics of linear elastic fracture mechanics under static and dynamic load,<br>• determination of lifetime of steel construction based on linear elastic fracture mechanics in different examples. |
| **Literature** | • Seeßelberg, C.; Kranbahnen - Bemessung und konstruktive Gestaltung; 3. Auflage; Bauwerk-Verlag; Berlin 2009<br>• Kuhlmann, Dürr, Günther; Kranbahnen und Betriebsfestigkeit; in Stahlbau Kalender 2003; Verlag Ernst & Sohn; Berlin 2003<br>• Deutscher Stahlbau-Verband (Hrsg.); Stahlbau Handbuch Band 1 Teil B; 3. Auflage; Stahlbau-Verlagsgesellschaft; Köln 1996<br>• Petersen, C.; Stahlbau; 3. überarb. und erw. Auflage; Vieweg-Verlag; Braunschweig 1993<br>• DIN V ENV 1993-1-1: Eurocode 3; Bemessung und Konstruktion von Stahlbauwerken; Teil 1-1: Allgemeine Bemessungsregeln, Bemessungsregeln für den Hochbau; 1993<br>• DIN V ENV 1993-6: Eurocode 3; Bemessung und Konstruktion von Stahlbauwerken; Teil 6: Kranbahnen; 2001<br>• DIN-Fachbericht 126. Richtlinie zur Anwendung von DIN V ENV 1993-6; Nationales Anwendungsdokument (NAD); Berlin 2002 |

| Course L0565: Fracture Mechanics and Fatigue | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Ingo Hadrych |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0860: Harbour Engineering and Harbour Planning

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Harbour Engineering (L0809) | Lecture | 2 | 2 |
| Harbour Engineering (L1414) | Project-/problem-based Learning | 1 | 2 |
| Port Planning and Port Construction (L0378) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Peter Fröhle |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of coastal engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are able to define in details and to choose design approaches for the functional design of a port and apply them to design tasks. They can design the fundamental elements of a port. |
| *Skills* | The students are able to select and apply appropriate approaches for the functional design of ports. |
| **Personal Competence** | |
| *Social Competence* | The students are able to deploy their gained knowledge in applied problems such as the functional design of ports. Additionaly, they will be able to work in team with engineers of other disciplines. |
| *Autonomy* | The students will be able to independently extend their knowledge and apply it to new problems. |
| **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** | The duration of the examination is 150 min. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks. |
| **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: Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory |

### Course L0809: Harbour Engineering

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Fundamentals of harbor engineering<br>  ◦ Maritime transportation and waterways engineering<br>  ◦ Ships<br>• Elements of harbors<br>  ◦ Harbor approaches and water-side harbor areas<br>  ◦ Terminal design and handling of cargo<br>  ◦ Quay-walls and piers<br>  ◦ Equipment of harbors<br>  ◦ Sluices and other special constructions<br>• Connection to inland transportation / inland waterway transportation<br>• Protection of harbors<br>  ◦ Breakwaters and Jetties<br>  ◦ Wave protection of harbors<br>• Fishery and other small harbors |
| **Literature** | Brinkmann, B.: Seehäfen, Springer 2005 |

| Course L1414: Harbour Engineering | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0378: Port Planning and Port Construction | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Frank Feindt |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Planning and implementation of major projects<br>• Market analysis and traffic relations<br>• Planning process and plan<br>• Port planning in urban neighborhood<br>• Development of the logistics center "Port of Hamburg" in the metropolis<br>• Quays and waterfront structure<br>• Special planning Law Harbor - securing of a flexible use of the port<br>• Dimensioning of quays<br>• Flood protection structures<br>• Port of Hamburg - Infrastructure and development<br>• Preparation of areas<br>• Scour formation in front of shore structures |
| **Literature** | Vorlesungsumdruck, s. www.tu-harburg.de/gbt |

## Module M0723: Design of Prestressed Structures and Concrete Bridges

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Design of Prestressed Structures and Concreet Bridges (L0603) | Lecture | 3 | 4 |
| Design of Prestressed Structures and Concreet Bridges (L0604) | Recitation Section (large) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Günter Rombach |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Detailed knowledge on the design of concrete structures. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students know the main bridge types, their applications and the various loads. They can explain the basic design methods. They can explain the design of a prestressed bridge. |
| *Skills* | The students are able to design reinforced or prestressed concrete bridges. |
| **Personal Competence** | |
| *Social Competence* | The students can design in teamwork a real concrete bridge. |
| *Autonomy* | The students are able to design a prestressed concrete bridge and discuss the problems and results with other students. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 minutes |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Structural Engineering: Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory |

| Course L0603: Design of Prestressed Structures and Concreet Bridges | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Günter Rombach |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | prestressed structures<br>• basis of prestressed structures<br>• differences between reinforced and prestressed concrete structures<br>• history of prestressing<br>• construction materials: concrete, tendons, ducts, anchorage systems<br>• construction: prestressing methods<br>• prestressing forces and member forces (friction, elongation)<br>• tendon layout<br>• time dependant prestressing losses<br>• design of prestressed structures<br>• design of anchorage region<br>• non-bonded prestressing<br>• prestressed flat slabs<br><br>Concrete bridges<br>• history of bridges<br>• design of bridges<br>• loads on bridges<br>• member forces for slab, T-beam, hollow box, frame and arch bridges<br>• precast bridges - precast segmental bridges<br>• bearings<br>• abutments, columns<br>• construction methods |
| **Literature** | • Vorlesungsumdruck<br>• Rombach, G. (2003): Spannbetonbau. Ernst & Sohn, Berlin<br>• Wicke, M. (2002): Anwendung des Spannbetons. Betonkalender 2002, Teil II, S. 113-180, Verlag Ernst & Sohn, Berlin<br>• Leonhardt, F. (1980): Vorlesungen über Massivbau. Teil 5: Spannbeton. Berlin<br>• Mehlhorn, G. (2007): Handbuch Brücken, Springer Verlag<br>• Schäfer, H.; Kaufeld, K. (1997): Massivbrücken. Betonkalender Teil II, S. 443ff, Ernst & Sohn, Berlin<br>• Menn, Ch. (1986): Stahlbetonbrücken. Springer Verlag, Wien |

| Course L0604: Design of Prestressed Structures and Concreet Bridges | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Günter Rombach |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0977: Construction Logistics and Project Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Construction Logistics (L1163) | Lecture | 1 | 2 |
| Construction Logistics (L1164) | Recitation Section (small) | 1 | 2 |
| Project Development and Management (L1161) | Lecture | 1 | 1 |
| Project Development and Management (L1162) | Project-/problem-based Learning | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Heike Flämig |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can...<br>• give definitions of the main terms of construction logistics and project development and management<br>• name advantages and disadvantages of internal or external construction logistics<br>• explain characteristics of products, demand and production of construction objects and their consequences for construction specific supply chains<br>• differentiate constructions logistics from other logistics systems |
| *Skills* | Students can...<br>• carry out project life cycle assessments<br>• apply methods and instruments of construction logistics<br>• apply methods and instruments of project development and management<br>• apply methods and instruments of conflict management<br>• design supply and waste removal concepts for a construction project |
| **Personal Competence** | |
| *Social Competence* | Students can...<br>• hold presentations in and for groups<br>• apply methods of conflict solving skills in group work and case studies |
| *Autonomy* | Students can...<br>• solve problems by holistic, systemic and flow oriented thinking<br>• improve their creativity, negotiation skills, conflict and crises solution skills by applying methods of moderation in case studies |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Two written papers with presentations |
| **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>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory<br>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 |

| Course L1163: Construction Logistics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Heike Flämig |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The lecture gives deeper insight how important logistics are as a competetive factor for construction projects and which issues are to be adressed.<br><br>The following toppics are covered:<br><br>• competetive factor logistics<br>• the concept of systems, planning and coordination of logistics<br>• material, equipment and reverse logistics<br>• IT in construction logistics<br>• elements of the planning model of construction logistics and their connections<br>• flow oriented logistics systems for construction projects<br>• logistics concepts for ready to use construction projects (especially procurement and waste removel logistics)<br>• best practice examples (construction logistics Potsdamer Platz, recent case study of the region)<br><br>Contents of the lecture are deepened in special exercises. |
| **Literature** | Flämig, Heike: Produktionslogistik in Stadtregionen. In: Forschungsverbund Ökologische Mobilität (Hrsg.) Forschungsbericht Bd. 15.2. Wuppertal 2000.<br><br>Krauss, Siri: Die Baulogistik in der schlüsselfertigen Ausführung,  Bauwerk Verlag GmbH Berlin 2005.<br><br>Lipsmeier, Klaus: Abfallkennzahlen für Neubauleistungen im Hochbau : Verlag Forum für Abfallwirtschaft und Altlasten, 2004.<br><br>Schmidt, Norbert: Wettbewerbsfaktor Baulogistik. Neue Wertschöpfungspotenziale in der Baustoffversorgung. In: Klaus, Peter: Edition Logistik. Band 6. Deutscher Verkehrs-Verlag. Hamburg 2003.<br><br>Seemann, Y.F. (2007): Logistikkoordination als Organisationseinheit bei der Bauausführung Wissenschaftsverlag Mainz in Aachen, Aachen. (Mitteilungen aus dem Fachgebiet Baubetrieb und Bauwirtschaft (Hrsg. Kuhne, V.): Heft 20) |

| Course L1164: Construction Logistics | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Heike Flämig |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1161: Project Development and Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Heike Flämig, Dr. Anton Worobei |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Within the lecture, the main aspects of project development and management are tought:<br><br>• Terms and definitions of project management<br>• Advantages and disadvantages of different ways of project handling<br>• organization, information, coordination and documentation<br>• cost and fincance management in projects<br>• time- and capacity management in projects<br>• specific methods and instruments for successful team work<br><br>Contents of the lecture are deepened in special exercises. |
| **Literature** | Projektmanagement-Fachmann. Band 1 und Band 2. RKW-Verlag, Eschborn, 2004. |

| Course L1162: Project Development and Management | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Heike Flämig, Dr. Anton Worobei |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0581: Water Protection

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Water Protection and Wastewater Management (L0226) | Lecture | 3 | 3 |
| Water Protection and Wastewater Management (L2008) | Project Seminar | 3 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Ralf Otterpohl |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Basic knowledge in water management;<br>• Good knowledge in urban drainage;<br>• Good knowledge of wastewater treatment techniques;<br>• Good knowledge of pollutants (e.g. COD, BOD, TS, N, P) and their properties; |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can describe the basic principles of the regulatory framework related to the international and European water sector. They can explain limnological processes, substance cycles and water morphology in detail. They are able to assess complex problems related to water protection, such as ecosystem service and wastewater treatment with a special focus on innovative solutions, remediation measures as well as conceptual approaches. |
| *Skills* | Students can accurately assess current problems and situations in a country-specific or local context. They can suggest concrete actions to contribute to the planning of tomorrow's urban water cycle. Furthermore, they can suggest appropriate technical, administrative and legislative solutions to solve these problems. |
| **Personal Competence** | |
| *Social Competence* | The students can work together in international groups. |
| *Autonomy* | Students are able to organize their work flow to prepare presentations and discussions. They can acquire appropriate knowledge by making enquiries independently. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Presentation |
| **Examination duration and scale** | Term paper plus presentation |
| **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>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Environmental Engineering: Specialisation Water: Elective Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory<br>Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Compulsory |

| Course L0226: Water Protection and Wastewater Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | The lecture focusses on:<br>• Regulatory Framework (e.g. WFD)<br>• Main instruments for the water management and protection<br>• In depth knowledge of relevant measures of water pollution control<br>• Urban drainage, treatment options in different regions on the world<br>• Rainwater management, improved management of heavy rainfalls, downpours, rainwater harvesting, rainwater infiltration<br>• Case Studies and Field Trips |
| **Literature** | The literature listed below is available in the library of the TUHH.<br>• Water and wastewater technology Hammer, M. J. 1., & . (2012). (7. ed., internat. ed.). Boston [u.a.]: Pearson Education International.<br>• Water and wastewater engineering : design principles and practice: Davis, M. L. 1. (2011). . New York, NY: McGraw-Hill.<br>• Biological wastewater treatment: (2011). C. P. Leslie Grady, Jr. (3. ed.). London, Boca Raton, Fla. [u.a.]: IWA Publ. |

| Course L2008: Water Protection and Wastewater Management | |
|---|---|
| **Typ** | Project Seminar |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | |

## Module M0595: Examination of Materials, Structural Condition and Damages

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Examination of Materials, Structural Condition and Damages (L0260) | Lecture | 3 | 4 |
| Examination of Materials, Structural Condition and Damages (L0261) | Recitation Section (small) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Frank Schmidt-Döhl |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge about building materials or material science, for example by the module Building Materials and Building Chemistry. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are able to describe the rules for trading, use and marking of construction products in Germany. They know which methods for the testing of building material properties are usable and know the limitations and characterics of the most important testing methods. |
| *Skills* | The students are able to responsibly discover the rules for trading and using of building products in Germany.<br>They are able to chose suitable methods for the testing and inspection of construction products, the examination of damages and the examination of the structural conditions of buildings. They are able to conclude from symptons to the cause of damages. They are able to  describe an examination in form of a test report or expert opinion. |
| **Personal Competence** | |
| *Social Competence* | The students can describe the different roles of manufacturers as well as testing, supervisory and certification bodies within the framework of material testing. They can describe the different roles of the participants in legal proceedings. |
| *Autonomy* | The students are able to make the timing and the operation steps to learn the specialist knowledge of a very extensive field. |
| **Workload in Hours** | Independent Study Time 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** | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory<br>Materials Science: Specialisation Engineering Materials: Elective Compulsory |

### Course L0260: Examination of Materials, Structural Condition and Damages

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Frank Schmidt-Döhl |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Materials testing and marking process of construction products, testing methods for building materials and structures, testing reports and expert opinions, describing the condition of a structure, from symptons to the cause of damages |
| **Literature** | Frank Schmidt-Döhl: Materialprüfung im Bauwesen. Fraunhofer irb-Verlag, Stuttgart, 2013. |

### Course L0261: Examination of Materials, Structural Condition and Damages

| | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Frank Schmidt-Döhl |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0603: Nonlinear Structural Analysis

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Nonlinear Structural Analysis (L0277) | Lecture | 3 | 4 |
| Nonlinear Structural Analysis (L0279) | Recitation Section (small) | 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 nonlinear phenomena in structural mechanics.<br>+ explain the mechanical background of nonlinear phenomena in structural mechanics.<br>+ to specify problems of nonlinear structural analysis, to identify them in a given situation and to explain their mathematical and mechanical background. |
| *Skills* | Students are able to<br>+ model nonlinear structural problems.<br>+ select for a given nonlinear structural problem a suitable computational procedure.<br>+ apply finite element procedures for nonlinear structural analysis.<br>+ critically verify and judge results of nonlinear finite elements.<br>+ to transfer their knowledge of nonlinear solution procedures to new problems. |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>+ solve problems in heterogeneous groups and to document the corresponding results.<br>+ share new knowledge with group members. |
| *Autonomy* | Students are able to<br>+ acquire independently knowledge to solve complex problems. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory<br>Materials Science: Specialisation Modeling: Elective Compulsory<br>Mechatronics: Specialisation System Design: Elective Compulsory<br>Product Development, Materials and Production: Core Qualification: Elective Compulsory<br>Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory<br>Ship and Offshore Technology: Core Qualification: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Simulation Technology: Elective Compulsory |

| Course L0277: Nonlinear Structural Analysis | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Alexander Düster |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | 1. Introduction<br>2. Nonlinear phenomena<br>3. Mathematical preliminaries<br>4. Basic equations of continuum mechanics<br>5. Spatial discretization with finite elements<br>6. Solution of nonlinear systems of equations<br>7. Solution of elastoplastic problems<br>8. Stability problems<br>9. Contact problems |
| **Literature** | [1] Alexander Düster, Nonlinear Structrual Analysis, Lecture Notes, Technische Universität Hamburg-Harburg, 2014.<br>[2] Peter Wriggers, Nonlinear Finite Element Methods, Springer 2008.<br>[3] Peter Wriggers, Nichtlineare Finite-Elemente-Methoden, Springer 2001.<br>[4] Javier Bonet and Richard D. Wood, Nonlinear Continuum Mechanics for Finite Element Analysis, Cambridge University Press, 2008. |

| Course L0279: Nonlinear Structural Analysis | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Alexander Düster |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0699: Geotechnics III

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Numerical Methods in Geotechnics (L0375) | Lecture | 3 | 3 |
| Advanced Foundation Engineering (L0497) | Lecture | 2 | 2 |
| Advanced Foundation Engineering (L0498) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Jürgen Grabe |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | |
| *Skills* | |
| **Personal Competence** | |
| *Social Competence* | |
| *Autonomy* | |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes; **Bonus** None; **Form** Subject theoretical and practical work; **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Structural Engineering: Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory |

### Course L0375: Numerical Methods in Geotechnics

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Dr. Hans Mathäus Stanford |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Topics:<br>• numerical simulations<br>• numerical algorithms<br>• finite element method<br>• application of finite element method in geomechanics<br>• constitutive models for soils<br>• contact models for soil structure interaction<br>• selected applications |
| **Literature** | • Wriggers P. (2001): Nichtlineare Finite-Elemente-Methoden, Springer Verlag, Berlin<br>• Bathe Klaus-Jürgen (2002): Finite-Elemente-Methoden. Springer Verlag, Berlin |

| Course L0497: Advanced Foundation Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Jürgen Grabe |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Vertical drains<br>• Piles<br>• Ground improvement (Deep Compaction, Soil mixing)<br>• Vibration driving<br>• Jet grouting<br>• Slurry wall<br>• Deep excavation |
| **Literature** | • EAK (2002): Empfehlungen für Küstenschutzbauwerke<br>• EAU (2004): Empfehlungen des Arbeitsausschusses Uferbauwerke<br>• EAB (1988): Empfehlungen des Arbeitskreises Baugruben<br>• Grundbau-Taschenbuch, Teil 1-3, (1997), Ernst & Sohn Verlag |

| Course L0498: Advanced Foundation Engineering | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Jürgen Grabe |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0713: Concrete Structures

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Concrete Structures (L0579) | Seminar | 1 | 1 |
| Structural Concrete Members (L0577) | Lecture | 2 | 3 |
| Structural Concrete Members (L0578) | Recitation Section (large) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Günter Rombach |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of structural analysis, conception and dimensioning of structural concrete<br><br>Modules: Reinforced Concrete Structures I+II, Structural Analysis I+II, Mechanics I+II |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students broaden their skills in structural engineering, especially in the field of buildings (houses, roofs, halls). They dispose of the knowledge for the conception and design of concrete buildings and structural members that are often used. |
| *Skills* | The students are able to apply procedures of the conception and dimensioning to to practical problems of structural engineering. They are capable to draft concrete buildings and to design them for general action effects and to plan their detailing and execution. Moreover, they can make design and construction sketches and draw up technical descriptions. |
| **Personal Competence** | |
| *Social Competence* | The students are able to obtain results of high quality in teamwork. |
| *Autonomy* | The students are able to carry out complex conception and dimensioning tasks of structures under the guidance of tutors. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes; **Bonus** None; **Form** Presentation; **Description** Es werden 2 Referate ausgegeben |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 minutes |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Structural Engineering: Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory |

### Course L0579: Concrete Structures

| | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Günter Rombach |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | With help of a project teamwork the subjects of the course "Concrete Structures" is practiced, discussed and presented. |
| **Literature** | - Projektbezogene Unterlagen werden abgegeben. |

| Course L0577: Structural Concrete Members | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Günter Rombach |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • skyscrapers: structural elements<br>• actions on structrues<br>• bracing systems<br>• design orf slabs (line and point supported plates and floor slabs)<br>• membranes and deep beams<br>• folded plates and shells<br>• truss models<br>• reinforced and prestressed members |
| **Literature** | Vorlesungsunterlagen können im STUDiP heruntergeladen werden<br>• Zilch K., Zehetmaier G.: Bemessung im konstruktiven Ingenieurbau. Springer, Heidelberg 2010<br>• König, G., Liphardt S.: Hochhäuser aus Stahlbeton, Betonkalender 2003, Teil II, Seite 1-69, Verlag Ernst & Sohn, Berlin 2003<br>• Phocas, Marios C.: Hochhäuser : Tragwerk und Konstruktion, Stuttgart, Teubner, 2005<br>• Deutscher Ausschuss für Stahlbeton: Heft 600: Erläuterungen zu DIN EN 1992-1-1, Beuth Verlag, Berlin 2012<br>• Deutscher Ausschuss für Stahlbeton: Heft 240: Hilfsmittel zur Berechnung der Schnittgrößen und Formänderungen von Stahlbetontragwerken, Verlag Ernst & Sohn, Berlin 1978<br>• Stiglat, K., Wippel, H.: Massive Platten - Ausgewählte Kapitel der Schnittkraftermittlung und Bemessung, Betonkalender 1992, Teil I, 287-366, Verlag Ernst & Sohn, Berlin 1992<br>• Stiglat/Wippel: Platten. Verlag Ernst & Sohn, Berlin,1973<br>• Schlaich J.; Schäfer K.: Konstruieren im Stahlbetonbau. Betonkalender 1998, Teil II, S. 721ff, Verlag Ernst & Sohn, Berlin, 1998<br>• Dames K.-H.: Rohbauzeichnungen Bewehrungszeichnungen. Bauverlag, Wiesbaden 1997 |

| Course L0578: Structural Concrete Members | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Günter Rombach |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0858: Coastal Hydraulic Engineering I

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Basics of Coastal Engineering (L0807) | Lecture | 3 | 4 |
| Basics of Coastal Engineering (L1413) | Project-/problem-based Learning | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Peter Fröhle |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of hydraulic engineering, hydrology and hydromechanics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are able to define and explain the basic concepts of coastal engineering and port engineering. They are able to apply the concepts to selected practical problems of coastal engineering. Students can define and determine the basics for design and dimensioning of coastal engineering constructions. |
| *Skills* | The students are capable to apply basic design approaches to selected and pre-defined design tasks in coastal engineering. |
| **Personal Competence** | |
| *Social Competence* | The students are able to deploy their gained knowledge in applied problems such as the design of coastal protection structures. Additionaly, they will be able to work in team with engineers of other disciplines, for instance designing of coastal breakwaters. |
| *Autonomy* | The students will be able to independently extend their knowledge and applyit to new 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** | The duration of the examination is 2 hours. The examination includes tasks with respect to the general understanding of the lecture contents and calculations tasks. |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory |

### Course L0807: Basics of Coastal Engineering

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Basics of planning and design<br>  ◦ Water levels<br>  ◦ Currents<br>  ◦ Waves<br>  ◦ Ice<br>• Planning and Design in Coastal Engineering<br>  ◦ Functional and constructional design<br>  ◦ Determination of design parameters<br>  ◦ Design-approaches<br>    ▪ Filter<br>    ▪ Rubble mound constructions<br>    ▪ Piles<br>    ▪ Vertical constructions |
| **Literature** | Coastal Engineering Manual, CEM<br><br>Vorlesungsumdruck |

| Course L1413: Basics of Coastal Engineering | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Peter Fröhle |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0962: Sustainability and Risk Management

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Safety, Reliability and Risk Assessment (L1145) | Seminar | 2 | 3 |
| Environment and Sustainability (L0319) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Kerstin Kuchta |
| **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 describe single techniques and to give an overview for the field of safety and risk assessment as well as environmental and sustainable engineering, in detail:<br>• basics in safety and reliability of technical facilities<br>• safety and reliability analysis methods<br>• risk assessment<br>• Production and usage of bio-char<br>• energy production and supply<br>• sustainable product design |
| *Skills* | Students are able apply interdisciplinary system-oriented methods for risk assessment and sustainability reporting. They can evaluate the effort and costs for processes and select economically feasible treatment concepts. |
| **Personal Competence** | |
| *Social Competence* | |
| *Autonomy* | Students can gain knowledge of the subject area from given sources and transform it to new questions. Furthermore, they can define targets for new application or research-oriented duties in for risk management and sustainability concepts accordance with the potential social, economic and cultural impact. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Elaboration and presentation (45 minutes in groups) |
| **Assignment for the Following Curricula** | Civil Engineering: Core Qualification: Compulsory<br>Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Management and Controlling: Elective Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: 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>Water and Environmental Engineering: Core Qualification: Compulsory |

### Course L1145: Safety, Reliability and Risk Assessment

| | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Marco Ritzkowski |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | An introduction in safety and risk assessment is given and some typical problems of structural and environmental engineering are treated:<br>• basics in safety and reliability of technical facilities<br>• safety and reliability analysis methods<br>• risk assessment<br>• practical examples and excursions<br>• discussions and presentations |
| **Literature** | - Vorlesungsunterlagen<br>- Schneider, J., Schlatter, H.P.: Sicherheit und Zuverlässigkeit im Bauwesen. www.risksafety.ch/files/**sicherheit**_und_zuverlaessigkeit.pdf |

| Course L0319: Environment and Sustainability | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | This course presents actual methodologies and examples of environmental relevant, sustainable technologies, concepts and strategies in the field of energy supply, product design, water supply, waste water treatment or mobility. The following list show examples.<br>Production and Usage of Bio-char<br>Engergy production with algae<br>Environmental product design<br>Clean Development mechanism (CDM)<br>Democracy and Energy<br>New Concepts for a sustainable Energy Supply<br><br>Recycling of Wind Turbines<br>Alternative Mobility<br><br>Disposal of Nuclear Wastes<br>Waste2Energy<br>Offshore Wind energy |
| **Literature** | Wird in der Veranstaltung bekannt gegeben. |

## Module M0963: Steel and Composite Structures

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Steel and Composite Structures (L1204) | Lecture | 2 | 2 |
| Steel and Composite Structures (L1205) | Recitation Section (large) | 2 | 2 |
| Steel Bridges (L1097) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Marcus Rutner |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of steel construction (i.e. Steel Structures I and II, BUBC) |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After successful completition, students can<br>• describe the phenomenon of local buckling<br>• explain warping torsion<br>• illustrate the behaviour of composite structures<br>• specify the principles in design of composite sttructures<br>• sketch the contructions of steel and composite bridges |
| *Skills* | After successful participation students are able to<br>• check stiffened and unstiffened plated structures<br>• recognize and verify warping tosion in strucures<br>• design composite structures<br>• design bridges and o perform the detailing |
| **Personal Competence** | |
| *Social Competence* | -- |
| *Autonomy* | -- |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Structural Engineering: Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory |

### Course L1204: Steel and Composite Structures

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Marcus Rutner |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Local-buckling of plated structures<br>• Warping torsion<br>• Composite-girders, -columns, -slabs, -bridges<br>• Principles in composite constructions<br>• Bridge-design and -construction |
| **Literature** | Petersen, C.: Stahlbau, 4.Auflage 2013, Springer-Vieweg Verlag<br><br>Minnert, J. Wagenknecht, G.: Verbundbau-Praxis - Berechnung und Konstruktion nach Eurocode 4, 2.Auflage 2013, Bauwerk Beuth Verlag |

| Course L1205: Steel and Composite Structures | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Marcus Rutner |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1097: Steel Bridges | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Jörg Ahlgrimm |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | **Lecture Contents ‚Steel Bridge Construction'**<br>**Dr.-Ing. Jörg Ahlgrimm**<br><br>- From tendering and contracting to completion - the development of a steel bridge<br>- Contents of a bridge static - structural details, examples of analysis in detail:<br>-> effective width in regard to the longitudinal stiffeners<br>-> Bearing point, bearing stiffener<br>-> Crossbeam breakthrough, crossbeam reinforcement<br>-> Analysis of the Rib-to-Floorbeam (RF) connection (web-tooth of the floorbeam between trapezoidal shaped Ribs)<br>- Steel grades, -designation, testing methods and approval certificates<br>- Nondestructive weld inspecting<br>- Corrosion protection<br>- Bridge bearing - types, format, function, dimensioning, installation<br>- Expansion Joints<br>- Oscillation of bridge hangers and cables - oscillation damper<br>- Opening bridges- Detailed reviews to different assembling procedures and - implements<br>- Selective damage events<br>Requirements: Basic knowledge in the calculation, dimensioning, and construction of structural elements and joints of constructional steelwork |
| **Literature** | • Herbert Schmidt, Ulrich Schulte, Rainer Zwätz, Lothar Bär:<br>Ausführung von Stahlbauten<br>• Petersen, Christian: Stahlbau, Abschnitt Brückenbau<br>• Ahlgrimm, J., Lohrer, I.: Erneuerung der Eisenbahnüberführung in Fulda-Horas über die Fulda, Stahlbau 74 (2005), Heft 2, S. 114 |

## Module M0964: Underground Constructions

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Applied Tunnel Constructions (L2407) | Lecture | 2 | 3 |
| Introduction to tunnel construction (L0707) | Lecture | 1 | 2 |
| Introduction to tunnel construction (L1811) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Jürgen Grabe |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Modules from Bachelor studies Civil and environmental engineering:<br>• Geotechnics I-II<br>• Steel Structures I-II |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Knowledge of different tunnel construction types as well as special methods and techniques of subsoil construction. The students get deeper knowledge of steel and ground engineering as well as constructions knowledge concerning quay walls. Futhermore, the students get all the neccessary knowledge to design singular construction elements for sheet pile walls and they know how to choose the right construction elements depending on the influencing conditions. |
| *Skills* | Basic knowledge of tunnel design as well as practical skills in structural tunnel analysis. Furthermore, the students are able to dimension sheet pile wall construction regarding all constrution elements, to choose the suitable construction elements with respect to the influencing conditions, to design all kinds of sheet pile walls (wave sheet pile walls and combined sheet pile walls) and to dimension all construction elements and connections. |
| **Personal Competence** | |
| *Social Competence* | Capacity for teamwork concerning project management and design of tunnels. |
| *Autonomy* | Promotion of independent and creative work flow in the framework of a design exercise. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 minutes |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory |

### Course L2407: Applied Tunnel Constructions

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Jürgen Grabe, Tim Babendererde |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | |

| Course L0707: Introduction to tunnel construction | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Dr. Marius Milatz |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Definitions<br>• Historical development in tunneling<br>• Geology for tunneling<br>• Hard rock tunneling (construction composite and machines)<br>• Tunnelung in temporarly stable soil with conventional construction methods<br>• Tunneling in soft soils (form of supports, shield types, compressed air application)<br>• Pipe jacking<br>• Tunnel Lining, tunnel supporting structures<br>• Calculation approaches for supporting structures in shield-driven tunnels<br>• Surveying for tunneling<br>• Safety requirements<br>• Construction Contract<br>• Literature and sources |
| **Literature** | • Vorlesung/Übung s. www.tu-harburg.de/gbt |

| Course L1811: Introduction to tunnel construction | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Marius Milatz |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Specialization II. Electrical Engineering

### Module M0712: Microwave Semiconductor Devices and Circuits I

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Microwave Semiconductor Devices and Circuits I (L0580) | Lecture | 3 | 4 |
| Microwave Semiconductor Devices and Circuits I (L0581) | Recitation Section (large) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Arne Jacob |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Electrical Engineering IV, Microwave Engineering, Fundamentals of Semiconductor Technology |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are capable of explaining the functionality of amplifier, mixer, and oscillator in detail. They can present theories, concepts, and reasonable assumptions for description and synthesis of these devices. They are able to apply thorough knowledge of semiconductor physics of selected microwave devices to amplifier, mixer, and oscillator. They can compare different devices with respect to various parameters (such as frequency range, power und efficiency). |
| *Skills* | The students can assess occurring linear and nonlinear effects in active microwave circuits and are capable of analyzing and evaluating them. They are able to develop passive and active linear microwave circuits with the help of modern software-tools, taking application requirements into account. |
| **Personal Competence** | |
| *Social Competence* | The students are able to carry out subject-specific tasks in small groups, and to adequately present solutions (e.g. in CAD-Exercises). |
| *Autonomy* | The students are able to obtain additional information from given literature sources and set the content in context with the lecture. They can link and deepen their knowledge of other courses, e.g., Electrical Engineering IV, Theoretical Engineering, Microwave Engineering, Semiconductor Devices. The students acquire the ability to communicate problems and solutions in the field of microwave semiconductor devices and circuits in English. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Oral exam |
| **Examination duration and scale** | 30 min |
| **Assignment for the Following Curricula** | Electrical Engineering: Specialisation Microwave Engineering, Optics, and Electromagnetic Compatibility: Elective Compulsory<br>International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory |

| Course L0580: Microwave Semiconductor Devices and Circuits I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Arne Jacob |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | - Amplifier: S-Parameters, stability, gain definitions; Bipolar Junction Transistor and HBT, MESFET and HEMT; Circuit applications, nonlinear distortions, low noise and power amplifier<br><br>- Mixer: Conversion matrix analysis; pn- and Schottky-diode, FET; Circuit applications, conversion gain and noise figure<br><br>- Oszillator: Oscillation start-up, steady state operation, stability; IMPATT-diode, Gunn-element, FET; oscillator stabilization<br><br>- Linear passive circuits: Planar microwave circuits, quarterwave matching circuits and discontinuities, lowpass-filter and bandpass-filter synthesis<br><br>- Design of active circuits |
| **Literature** | - E. Voges, „Hochfrequenztechnik“, Hüthig (2004)<br><br>- H.-G. Unger, W. Harth, „Hochfrequenz-Halbleiterelektronik“, S. Hirzel Verlag (1972)<br><br>- S.M. Sze, „Physics of Semiconductor Devices”, John Wiley & Sons (1981)<br>- A. Jacob, „Lecture Notes Microwave Semiconductor Devices and Circuits Part I“ |

| Course L0581: Microwave Semiconductor Devices and Circuits I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Arne Jacob |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0630: Robotics and Navigation in Medicine

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Robotics and Navigation in Medicine (L0335) | Lecture | 2 | 3 |
| Robotics and Navigation in Medicine (L0338) | Project Seminar | 2 | 2 |
| Robotics and Navigation in Medicine (L0336) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Alexander Schlaefer |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • principles of math (algebra, analysis/calculus)<br>• principles of programming, e.g., in Java or C++<br>• solid R or Matlab skills |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can explain kinematics and tracking systems in clinical contexts and illustrate systems and their components in detail. Systems can be evaluated with respect to collision detection and safety and regulations. Students can assess typical systems regarding design and limitations. |
| *Skills* | The students are able to design and evaluate navigation systems and robotic systems for medical applications. |
| **Personal Competence** | |
| *Social Competence* | The students discuss the results of other groups, provide helpful feedback and can incoorporate feedback into their work. |
| *Autonomy* | The students can reflect their knowledge and document the results of their work. They can present the results in an appropriate manner. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>Yes / 10 % / Written elaboration<br>Yes / 10 % / Presentation |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | Computer Science: Specialisation Intelligence Engineering: Elective Compulsory<br>Electrical Engineering: Specialisation Medical Technology: Elective Compulsory<br>International Management and Engineering: Specialisation II. Electrical Engineering: 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: 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: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory |

| Course L0335: Robotics and Navigation in Medicine | |
|---|---|
| **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** | SoSe |
| **Content** | - kinematics<br>- calibration<br>- tracking systems<br>- navigation and image guidance<br>- motion compensation<br>The seminar extends and complements the contents of the lecture with respect to recent research results. |
| **Literature** | Spong et al.: Robot Modeling and Control, 2005<br>Troccaz: Medical Robotics, 2012<br>Further literature will be given in the lecture. |

| Course L0338: Robotics and Navigation in Medicine | |
|---|---|
| **Typ** | Project Seminar |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Alexander Schlaefer |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0336: Robotics and Navigation in Medicine | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Alexander Schlaefer |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0918: Fundamentals of IC Design

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fundamentals of IC Design (L0766) | Lecture | 2 | 3 |
| Fundamentals of IC Design (L1057) | Practical Course | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Matthias Kuhl |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals of electrical engineering, electronic devices and circuits |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can explain the basic structure of the circuit simulator SPICE.<br>• Students are able to describe the differences between the MOS transistor models of the circuit simulator SPICE.<br>• Students can discuss the different concept for realization the hardware of electronic circuits.<br>• Students can exemplify the approaches for “Design for Testability”.<br>• Students can specify models for calculation of the reliability of electronic circuits. |
| *Skills* | • Students can determine the input parameters for the circuit simulation program SPICE.<br>• Students can select the most appropriate MOS modelling approaches for circuit simulations.<br>• Students can quantify the trade-off of different design styles.<br>• Students can determine the lot sizes and costs for reliability analysis. |
| **Personal Competence** | |
| *Social Competence* | • Students can compile design studies by themselves or together with partners.<br>• Students are able to select the most efficient design methodology for a given task.<br>• Students are able to define the work packages for design teams. |
| *Autonomy* | • Students are able to assess the strengths and weaknesses of their design work in a self-contained manner.<br>• Students can name and bring together all the tools required for total design flow. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | Electrical Engineering: Specialisation Nanoelectronics and Microsystems Technology: Elective Compulsory<br>International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory<br>Microelectronics and Microsystems: Core Qualification: Elective Compulsory |

| Course L0766: Fundamentals of IC 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** | DE/EN |
| **Cycle** | SoSe |
| **Content** | • Circuit-Simulator SPICE<br>• SPICE-Models for MOS transistors<br>• IC design<br>• Technology of MOS circuits<br>• Standard cell design<br>• Design of gate arrays<br>• Examples for realization of ASICs in the institute of nanoelectronics<br>• Reliability of integrated circuits<br>• Testing of integrated circuits |
| **Literature** | R. J. Baker, „CMOS-Circuit Design, Layout, and Simulation“, Wiley & Sons, IEEE Press, 2010<br><br>X. Liu, VLSI-Design Methodology Demystified; IEEE, 2009<br>N. Van Helleputte, J. M. Tomasik, W. Galjan, A. Mora-Sanchez, D. Schroeder, W. H. Krautschneider, R. Puers, A flexible system-on-chip (SoC) for biomedical signal acquisition and processing, Sensors and Actuators A: Physical, vol. 142, p. 361-368, 2008. |

| Course L1057: Fundamentals of IC Design | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Matthias Kuhl |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0551: Pattern Recognition and Data Compression

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Pattern Recognition and Data Compression (L0128) | Lecture | 4 | 6 |

| | |
|---|---|
| **Module Responsible** | Prof. Rolf-Rainer Grigat |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Linear algebra (including PCA, unitary transforms), stochastics and statistics, binary arithmetics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can name the basic concepts of pattern recognition and data compression.<br><br>Students are able to discuss logical connections between the concepts covered in the course and to explain them by means of examples. |
| *Skills* | Students can apply statistical methods to classification problems in pattern recognition and to prediction in data compression. On a sound theoretical and methodical basis they can analyze characteristic value assignments and classifications and describe data compression and video signal coding. They are able to use highly sophisticated methods and processes of the subject area. Students are capable of assessing different solution approaches in multidimensional decision-making areas. |
| **Personal Competence** | |
| *Social Competence* | k.A. |
| *Autonomy* | Students are capable of identifying problems independently and of solving them scientifically, using the methods they have learnt. |
| **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>Electrical Engineering: Specialisation Information and Communication Systems: 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>International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory<br>International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory<br>Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory<br>Mechatronics: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory |

| Course L0128: Pattern Recognition and Data Compression | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 4 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Lecturer** | Prof. Rolf-Rainer Grigat |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | Structure of a pattern recognition system, statistical decision theory, classification based on statistical models, polynomial regression, dimension reduction, multilayer perceptron regression, radial basis functions, support vector machines, unsupervised learning and clustering, algorithm-independent machine learning, mixture models and EM, adaptive basis function models and boosting, Markov random fields<br><br>Information, entropy, redundancy, mutual information, Markov processes, basic coding schemes (code length, run length coding, prefix-free codes), entropy coding (Huffman, arithmetic coding), dictionary coding (LZ77/Deflate/LZMA2, LZ78/LZW), prediction, DPCM, CALIC, quantization (scalar and vector quantization), transform coding, prediction, decorrelation (DPCM, DCT, hybrid DCT, JPEG, JPEG-LS), motion estimation, subband coding, wavelets, HEVC (H.265,MPEG-H) |
| **Literature** | Schürmann: Pattern Classification, Wiley 1996<br>Murphy, Machine Learning, MIT Press, 2012<br>Barber, Bayesian Reasoning and Machine Learning, Cambridge, 2012<br>Duda, Hart, Stork: Pattern Classification, Wiley, 2001<br>Bishop: Pattern Recognition and Machine Learning, Springer 2006<br><br>Salomon, Data Compression, the Complete Reference, Springer, 2000<br>Sayood, Introduction to Data Compression, Morgan Kaufmann, 2006<br>Ohm, Multimedia Communication Technology, Springer, 2004<br>Solari, Digital video and audio compression, McGraw-Hill, 1997<br>Tekalp, Digital Video Processing, Prentice Hall, 1995 |

## Module M0673: Information Theory and Coding

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Information Theory and Coding (L0436) | Lecture | 3 | 4 |
| Information Theory and Coding (L0438) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Gerhard Bauch |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Mathematics 1-3<br>• Probability theory and random processes<br>• Basic knowledge of communications engineering (e.g. from lecture "Fundamentals of Communications and Random Processes") |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students know the basic definitions for quantification of information in the sense of information theory. They know Shannon's source coding theorem and channel coding theorem and are able to determine theoretical limits of data compression and error-free data transmission over noisy channels. They understand the principles of source coding as well as error-detecting and error-correcting channel coding. They are familiar with the principles of decoding, in particular with modern methods of iterative decoding. They know fundamental coding schemes, their properties and decoding algorithms. |
| *Skills* | The students are able to determine the limits of data compression as well as of data transmission through noisy channels and based on those limits to design basic parameters of a transmission scheme. They can estimate the parameters of an error-detecting or error-correcting channel coding scheme for achieving certain performance targets. They are able to compare the properties of basic channel coding and decoding schemes regarding error correction capabilities, decoding delay, decoding complexity and to decide for a suitable method. They are capable of implementing basic coding and decoding schemes in software. |
| **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 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | Computer Science: Specialisation Intelligence Engineering: Elective Compulsory<br>Electrical Engineering: Specialisation Information and Communication Systems: Elective Compulsory<br>Computational Science and Engineering: Specialisation II. Engineering Science: Elective Compulsory<br>Information and Communication Systems: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory<br>Mechatronics: Technical Complementary Course: Elective Compulsory |

| Course L0436: Information Theory and Coding | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Gerhard Bauch |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | • Fundamentals of information theory<br>  ◦ Self information, entropy, mutual information<br>  ◦ Source coding theorem, channel coding theorem<br>  ◦ Channel capacity of various channels<br>• Fundamental source coding algorithms:<br>  ◦ Huffman Code, Lempel Ziv Algorithm<br>• Fundamentals of channel coding<br>  ◦ Basic parameters of channel coding and respective bounds<br>  ◦ Decoding principles: Maximum-A-Posteriori Decoding, Maximum-Likelihood Decoding, Hard-Decision-Decoding and Soft-Decision-Decoding<br>  ◦ Error probability<br>• Block codes<br>• Low Density Parity Check (LDPC) Codes and iterative Ddecoding<br>• Convolutional codes and Viterbi-Decoding<br>• Turbo Codes and iterative decoding<br>• Coded Modulation |
| **Literature** | Bossert, M.: Kanalcodierung. Oldenbourg.<br>Friedrichs, B.: Kanalcodierung. Springer.<br>Lin, S., Costello, D.: Error Control Coding. Prentice Hall.<br>Roth, R.: Introduction to Coding Theory.<br>Johnson, S.: Iterative Error Correction. Cambridge.<br>Richardson, T., Urbanke, R.: Modern Coding Theory. Cambridge University Press.<br>Gallager, R. G.: Information theory and reliable communication. Whiley-VCH<br>Cover, T., Thomas, J.: Elements of information theory. Wiley. |

| Course L0438: Information Theory and Coding | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Gerhard Bauch |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0548: Bioelectromagnetics: Principles and Applications

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Bioelectromagnetics: Principles and Applications (L0371) | Lecture | 3 | 5 |
| Bioelectromagnetics: Principles and Applications (L0373) | Recitation Section (small) | 2 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Christian Schuster |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic principles of physics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can explain the basic principles, relationships, and methods of bioelectromagnetics, i.e. the quantification and application of electromagnetic fields in biological tissue. They can define and exemplify the most important physical phenomena and order them corresponding to wavelength and frequency of the fields. They can give an overview over measurement and numerical techniques for characterization of electromagnetic fields in practical applications . They can give examples for therapeutic and diagnostic utilization of electromagnetic fields in medical technology. |
| *Skills* | Students know how to apply various methods to characterize the behavior of electromagnetic fields in biological tissue. In order to do this they can relate to and make use of the elementary solutions of Maxwell's Equations. They are able to assess the most important effects that these models predict for biological tissue, they can order the effects corresponding to wavelength and frequency, respectively, and they can analyze them in a quantitative way. They are able to develop validation strategies for their predictions. They are able to evaluate the effects of electromagnetic fields for therapeutic and diagnostic applications and make an appropriate choice. |
| **Personal Competence** | |
| *Social Competence* | Students are able to work together on subject related tasks in small groups. They are able to present their results effectively in English (e.g. during small group exercises). |
| *Autonomy* | Students are capable to gather information from subject related, professional publications and relate that information to the context of the lecture. They are able to make a connection between their knowledge obtained in this lecture with the content of other lectures (e.g. theory of electromagnetic fields, fundamentals of electrical engineering / physics). They can communicate problems and effects in the field of bioelectromagnetics in English. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes, **Bonus** 10 %, **Form** Presentation, **Description** |
| **Examination** | Oral exam |
| **Examination duration and scale** | 45 min |
| **Assignment for the Following Curricula** | Electrical Engineering: Specialisation Medical Technology: Elective Compulsory<br>Electrical Engineering: Specialisation Microwave Engineering, Optics, and Electromagnetic Compatibility: Elective Compulsory<br>International Management and Engineering: Specialisation II. Electrical Engineering: 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>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory |

| Course L0371: Bioelectromagnetics: Principles and Applications | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 5 |
| **Workload in Hours** | Independent Study Time 108, Study Time in Lecture 42 |
| **Lecturer** | Prof. Christian Schuster |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | - Fundamental properties of electromagnetic fields (phenomena)<br><br>- Mathematical description of electromagnetic fields (Maxwell's Equations)<br><br>- Electromagnetic properties of biological tissue<br><br>- Principles of energy absorption in biological tissue, dosimetry<br><br>- Numerical methods for the computation of electromagnetic fields (especially FDTD)<br><br>- Measurement techniques for characterization of electromagnetic fields<br><br>- Behavior of electromagnetic fields of low frequency in biological tissue<br><br>- Behavior of electromagnetic fields of medium frequency in biological tissue<br><br>- Behavior of electromagnetic fields of high frequency in biological tissue<br><br>- Behavior of electromagnetic fields of very high frequency in biological tissue<br><br>- Diagnostic applications of electromagnetic fields in medical technology<br><br>- Therapeutic applications of electromagnetic fields in medical technology<br><br>- The human body as a generator of electromagnetic fields |
| **Literature** | - C. Furse, D. Christensen, C. Durney, "Basic Introduction to Bioelectromagnetics", CRC (2009)<br><br>- A. Vorst, A. Rosen, Y. Kotsuka, "RF/Microwave Interaction with Biological Tissues", Wiley (2006)<br><br>- S. Grimnes, O. Martinsen, "Bioelectricity and Bioimpedance Basics", Academic Press (2008)<br><br>- F. Barnes, B. Greenebaum, "Bioengineering and Biophysical Aspects of Electromagnetic Fields", CRC (2006) |

| Course L0373: Bioelectromagnetics: Principles and Applications | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 2, Study Time in Lecture 28 |
| **Lecturer** | Prof. Christian Schuster |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0925: Digital Circuit Design

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

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

| Course L0698: Digital Circuit Design | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Volkhard Klinger |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | |

| Course L0699: Advanced Digital Circuit Design | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Volkhard Klinger |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | |
| **Literature** | |

## Module 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** No; **Bonus** 10 %; **Form** Presentation; **Description** |
| **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><br>Scaling Rules<br><br>Lithography<br><br>Film deposition<br><br>Structuring and etching<br><br>Energy conversion and force generation<br><br>Electromagnetic Actuators<br><br>Reluctance motors<br><br>Piezoelectric actuators, bi-metal-actuator<br><br>Transducer principles<br><br>Signal detection and signal processing<br><br>Mechanical and physical sensors<br><br>Acceleration sensor, pressure sensor<br><br>Sensor arrays<br><br>System integration<br><br>Yield, test and reliability |
| **Literature** | M. Kasper: Mikrosystementwurf, Springer (2000)<br><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><br>Layout consideration<br><br>Electric, thermal and mechanical behaviour<br><br>Design aspects |
| **Literature** | Wird in der Veranstaltung bekannt gegeben |

## 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>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 M0710: Microwave Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Microwave Engineering (L0573) | Lecture | 2 | 3 |
| Microwave Engineering (L0574) | Recitation Section (large) | 2 | 2 |
| Microwave Engineering (L0575) | Practical Course | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Alexander Kölpin |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals of communication engineering, semiconductor devices and circuits. Basics of Wave propagation from transmission line theory and theoretical electrical engineering. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can explain the propagation of electromagnetic waves and related phenomena. They can describe transmission systems and components. They can name different types of antennas and describe the main characteristics of antennas. They can explain noise in linear circuits, compare different circuits using characteristic numbers and select the best one for specific scenarios. |
| *Skills* | Students are able to calculate the propagation of electromagnetic waves. They can analyze complete transmission systems und configure simple receiver circuits. They can calculate the characteristic of simple antennas and arrays based on the geometry. They can calculate the noise of receivers and the signal-to-noise-ratio of transmission systems. They can apply their theoretical knowledge to the practical courses. |
| **Personal Competence** | |
| *Social Competence* | Students work together in small groups during the practical courses. Together they document, evaluate and discuss their results. |
| *Autonomy* | Students are able to relate the knowledge gained in the course to contents of previous lectures. With given instructions they can extract data needed to solve specific problems from external sources. They are able to apply their knowledge to the laboratory courses using the given instructions. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **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: Core Qualification: Compulsory<br>Information and Communication Systems: Specialisation Communication Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory<br>Microelectronics and Microsystems: Specialisation Communication and Signal Processing: Elective Compulsory |

| Course L0573: Microwave Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Arne Jacob |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | - Antennas: Analysis - Characteristics - Realizations<br>- Radio Wave Propagation<br>- Transmitter: Power Generation with Vacuum Tubes and Transistors<br>- Receiver: Preamplifier - Heterodyning - Noise<br>- Selected System Applications |
| **Literature** | H.-G. Unger, „Elektromagnetische Theorie für die Hochfrequenztechnik, Teil I“, Hüthig, Heidelberg, 1988<br>H.-G. Unger, „Hochfrequenztechnik in Funk und Radar“, Teubner, Stuttgart, 1994<br>E. Voges, „Hochfrequenztechnik - Teil II: Leistungsröhren, Antennen und Funkübertragung, Funk- und Radartechnik“, Hüthig, Heidelberg, 1991<br>E. Voges, „Hochfrequenztechnik“, Hüthig, Bonn, 2004<br>C.A. Balanis, “Antenna Theory”, John Wiley and Sons, 1982<br>R. E. Collin, “Foundations for Microwave Engineering”, McGraw-Hill, 1992<br>D. M. Pozar, “Microwave and RF Design of Wireless Systems”, John Wiley and Sons, 2001<br>D. M. Pozar, “Microwave Engineerin”, John Wiley and Sons, 2005 |

| Course L0574: Microwave Engineering | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Arne Jacob |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0575: Microwave Engineering | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Arne Jacob |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1048: Integrated Circuit Design

**Courses**

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

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

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

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

## Module M0676: Digital Communications

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Digital Communications (L0444) | Lecture | 2 | 3 |
| Digital Communications (L0445) | Recitation Section (large) | 2 | 2 |
| Laboratory Digital Communications (L0646) | Practical Course | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Gerhard Bauch |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Mathematics 1-3<br>• Signals and Systems<br>• Fundamentals of Communications and Random Processes |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are able to understand, compare and design modern digital information transmission schemes. They are familiar with the properties of linear and non-linear digital modulation methods. They can describe distortions caused by transmission channels and design and evaluate detectors including channel estimation and equalization. They know the principles of single carrier transmission and multi-carrier transmission as well as the fundamentals of basic multiple access schemes. |
| *Skills* | The students are able to design and analyse a digital information transmission scheme including multiple access. They are able to choose a digital modulation scheme taking into account transmission rate, required bandwidth, error probability, and further signal properties. They can design an appropriate detector including channel estimation and equalization taking into account performance and complexity properties of suboptimum solutions. They are able to set parameters of a single carrier or multi carrier transmission scheme and trade the properties of both approaches against each other. |
| **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** | **Compulsory** Yes · **Bonus** None · **Form** Written elaboration · **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | Electrical Engineering: Core Qualification: Compulsory<br>Computational Science and Engineering: Specialisation II. Engineering Science: Elective Compulsory<br>Information and Communication Systems: Specialisation Communication Systems: Compulsory<br>Information and Communication Systems: Specialisation Secure and Dependable IT Systems, Focus Networks: Elective Compulsory<br>International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory<br>International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory<br>Microelectronics and Microsystems: Core Qualification: Elective Compulsory |

| Course L0444: Digital Communications | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Gerhard Bauch |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | • Digital modulation methods<br>• Coherent and non-coherent detection<br>• Channel estimation and equalization<br>• Single-Carrier- and multi carrier transmission schemes, multiple access schemes (TDMA, FDMA, CDMA, OFDM) |
| **Literature** | K. Kammeyer: Nachrichtenübertragung, Teubner<br>P.A. Höher: Grundlagen der digitalen Informationsübertragung, Teubner.<br>J.G. Proakis, M. Salehi: Digital Communications. McGraw-Hill.<br>S. Haykin: Communication Systems. Wiley<br>R.G. Gallager: Principles of Digital Communication. Cambridge<br>A. Goldsmith: Wireless Communication. Cambridge.<br>D. Tse, P. Viswanath: Fundamentals of Wireless Communication. Cambridge. |

| Course L0445: Digital Communications | |
|---|---|
| **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** | DE/EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0646: Laboratory Digital Communications | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Gerhard Bauch |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | - DSL transmission<br>- Random processes<br>- Digital data transmission |
| **Literature** | K. Kammeyer: Nachrichtenübertragung, Teubner<br>P.A. Höher: Grundlagen der digitalen Informationsübertragung, Teubner.<br>J.G. Proakis, M. Salehi: Digital Communications. McGraw-Hill.<br>S. Haykin: Communication Systems. Wiley<br>R.G. Gallager: Principles of Digital Communication. Cambridge<br>A. Goldsmith: Wireless Communication. Cambridge.<br>D. Tse, P. Viswanath: Fundamentals of Wireless Communication. Cambridge. |

# Specialization II. Energy and Environmental Engineering

## Module M0511: Electricity Generation from Wind and Hydro Power

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Renewable Energy Projects in Emerged Markets (L0014) | Project Seminar | 1 | 1 |
| Hydro Power Use (L0013) | Lecture | 1 | 1 |
| Wind Turbine Plants (L0011) | Lecture | 2 | 3 |
| Wind Energy Use - Focus Offshore (L0012) | Lecture | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Dr. Joachim Gerth |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Module: Technical Thermodynamics I,<br><br>Module: Technical Thermodynamics II,<br><br>Module: Fundamentals of Fluid Mechanics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | By ending this module students can explain in detail knowledge of wind turbines with a particular focus of wind energy use in offshore conditions and can critical comment these aspects in consideration of current developments. Furthermore, they are able to describe fundamentally the use of water power to generate electricity. The students reproduce and explain the basic procedure in the implementation of renewable energy projects in countries outside Europe.<br><br>Through active discussions of various topics within the seminar of the module, students improve their understanding and the application of the theoretical background and are thus able to transfer what they have learned in practice. |
| *Skills* | Students are able to apply the acquired theoretical foundations on exemplary water or wind power systems and evaluate and assess technically the resulting relationships in the context of dimensioning and operation of these energy systems. They can in compare critically the special procedure for the implementation of renewable energy projects in countries outside Europe with the in principle applied approach in Europe and can apply this procedure on exemplary theoretical projects. |
| **Personal Competence** | |
| *Social Competence* | Students can discuss scientific tasks subjet-specificly and multidisciplinary within a seminar. |
| *Autonomy* | Students can independently exploit sources in the context of the emphasis of the lecture material to clear the contents of the lecture and to acquire the particular knowledge about the subject area. |
| **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** | 3 hours written exam |
| **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 and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: 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>Renewable Energies: Core Qualification: Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

| Course L0014: Renewable Energy Projects in Emerged Markets | |
|---|---|
| **Typ** | Project Seminar |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Andreas Wiese |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction<br>◦ Development of renewable energies worldwide<br>▪ History<br>▪ Future markets<br>◦ Special challenges in new markets - Overview<br>2. Sample project wind farm Korea<br>◦ Survey<br>◦ Technical Description<br>◦ Project phases and characteristics<br>3. Funding and financing instruments for EE projects in new markets<br>◦ Overview funding opportunitie<br>◦ Overview countries with feed-in laws<br>◦ Major funding programs<br>4. CDM projects - why, how , examples<br>◦ Overview CDM process<br>◦ Examples<br>◦ Exercise CDM<br>5. Rural electrification and hybrid systems - an important future market for EE<br>◦ Rural Electrification - Introduction<br>◦ Types of Elektrizifierungsprojekten<br>◦ The role of the EEInterpretation of hybrid systems<br>◦ Project example: hybrid system Galapagos Islands<br>6. Tendering process for EE projects - examples<br>◦ South Africa<br>◦ Brazil<br>7. Selected projects from the perspective of a development bank - Wesley Urena Vargas, KfW Development Bank<br>◦ Geothermal<br>◦ Wind or CSP<br><br>Within the seminar, the various topics are actively discussed and applied to various cases of application. |
| **Literature** | Folien der Vorlesung |

| Course L0013: Hydro Power Use | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Stefan Achleitner |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Introduction, importance of water power in the national and global context<br>• Physical basics: Bernoulli's equation, usable height of fall, hydrological measures, loss mechanisms, efficiencies<br>• Classification of Hydropower: Flow and Storage hydropower, low and high pressure systems<br>• Construction of hydroelectric power plants: description of the individual components and their technical system interaction<br>• Structural engineering components; representation of dams, weirs, dams, power houses, computer systems, etc.<br>• Energy Technical Components: Illustration of the different types of hydraulic machinery, generators and grid connection<br>• Hydropower and the Environment<br>• Examples from practice |
| **Literature** | • Schröder, W.; Euler, G.; Schneider, K.: Grundlagen des Wasserbaus; Werner, Düsseldorf, 1999, 4. Auflage<br>• Quaschning, V.: Regenerative Energiesysteme: Technologie - Berechnung - Simulation; Carl Hanser, München, 2011, 7. Auflage<br>• Giesecke, J.; Heimerl, S.; Mosony, E.: Wasserkraftanlagen - Planung, Bau und Betrieb; Springer, Berlin, Heidelberg, 2009, 5. Auflage<br>• von König, F.; Jehle, C.: Bau von Wasserkraftanlagen - Praxisbezogene Planungsunterlagen; C. F. Müller, Heidelberg, 2005, 4. Auflage<br>• Strobl, T.; Zunic, F.: Wasserbau: Aktuelle Grundlagen - Neue Entwicklungen; Springer, Berlin, Heidelberg, 2006 |

| Course L0011: Wind Turbine Plants | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Rudolf Zellermann, Dr. Jochen Oexmann |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Historical development<br>• Wind: origins, geographic and temporal distribution, locations<br>• Power coefficient, rotor thrust<br>• Aerodynamics of the rotor<br>• Operating performance<br>• Power limitation, partial load, pitch and stall control<br>• Plant selection, yield prediction, economy<br>• Excursion |
| **Literature** | Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005 |

| Course L0012: Wind Energy Use - Focus Offshore | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Martin Skiba |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Introduction, importance of offshore wind power generation, Specific requirements for offshore engineering<br>• Physical fundamentals for utilization of wind energy<br>• Design and operation of offshore wind turbines, presentation of different concepts of offshore wind turbines, representation of the individual system components and their system-technical relationships<br>• Foundation engineering, offshore site investigation, presentation of different concepts of offshore foundation structures, planning and fabrication of foundation structures<br>• Electrical infrastructure of an offshore wind farm, Inner Park cabling, offshore substation, grid connection<br>• Installation of offshore wind farms, installation techniques and auxiliary devices, construction logistics<br>• Development and planning of offshore wind farms<br>• Operation and optimization of offshore wind farms<br>• Day excursion |
| **Literature** | • Gasch, R.; Twele, J.: Windkraftanlagen - Grundlagen, Entwurf, Planung und Betrieb; Vieweg + Teubner, Stuttgart, 2007, 7. Auflage<br>• Molly, J. P.: Windenergie - Theorie, Anwendung, Messung; C. F. Müller, Heidel-berg, 1997, 3. Auflage<br>• Hau, E.: Windkraftanalagen; Springer, Berlin, Heidelberg, 2008, 4.Auflage<br>• Heier, S.: Windkraftanlagen - Systemauslegung, Integration und Regelung; Vieweg + Teubner, Stuttgart, 2009, 5. Auflage<br>• Jarass, L.; Obermair, G.M.; Voigt, W.: Windenergie: Zuverlässige Integration in die Energieversorgung; Springer, Berlin, Heidelberg, 2009, 2. Auflage |

## Module M0874: Wastewater Systems

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Wastewater Systems - Collection, Treatment and Reuse (L0934) | Lecture | 2 | 2 |
| Wastewater Systems - Collection, Treatment and Reuse (L0943) | Recitation Section (large) | 1 | 1 |
| Advanced Wastewater Treatment (L0357) | Lecture | 2 | 2 |
| Advanced Wastewater Treatment (L0358) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Ralf Otterpohl |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Knowledge of wastewater management and the key processes involved in wastewater treatment. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to outline key areas of the full range of treatment systems in waste water management, as well as their mutual dependence for sustainable water protection. They can describe relevant economic, environmental and social factors. |
| *Skills* | Students are able to pre-design and explain the available wastewater treatment processes and the scope of their application in municipal and for some industrial treatment plants. |
| **Personal Competence** | |
| *Social Competence* | Social skills are not targeted in this module. |
| *Autonomy* | Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Energy and Environmental Engineering: Specialisation Environmental Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Water: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Compulsory |

| Course L0934: Wastewater Systems - Collection, Treatment and Reuse | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | •Understanding the global situation with water and wastewater<br>•Regional planning and decentralised systems<br><br>•Overview on innovative approaches<br><br>•In depth knowledge on advanced wastewater treatment options for different situations, for end-of-pipe and reuse<br><br>•Mathematical Modelling of Nitrogen Removal<br><br>•Exercises with calculations and design |
| **Literature** | Henze, Mogens:<br>Wastewater Treatment: Biological and Chemical Processes, Springer 2002, 430 pages<br><br>George Tchobanoglous, Franklin L. Burton, H. David Stensel:<br>Wastewater Engineering: Treatment and Reuse, Metcalf & Eddy<br>McGraw-Hill, 2004 - 1819 pages |

| Course L0943: Wastewater Systems - Collection, Treatment and Reuse | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0357: Advanced Wastewater Treatment | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Joachim Behrendt |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Survey on advanced wastewater treatment<br><br>reuse of reclaimed municipal wastewater<br><br>Precipitation<br><br>Flocculation<br><br>Depth filtration<br><br>Membrane Processes<br><br>Activated carbon adsorption<br><br>Ozonation<br><br>"Advanced Oxidation Processes"<br><br>Disinfection |
| **Literature** | Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003<br><br>Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987<br><br>Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007<br><br>Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006<br><br>Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003 |

| Course L0358: Advanced Wastewater Treatment | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Joachim Behrendt |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Aggregate organic compounds (sum parameters)<br><br>Industrial wastewater<br><br>Processes for industrial wastewater treatment<br><br>Precipitation<br><br>Flocculation<br><br>Activated carbon adsorption<br><br>Recalcitrant organic compounds |
| **Literature** | Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003<br><br>Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987<br><br>Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007<br><br>Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006<br><br>Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003 |

## Module M0512: Use of Solar Energy

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Energy Meteorology (L0016) | Lecture | 1 | 1 |
| Energy Meteorology (L0017) | Recitation Section (small) | 1 | 1 |
| Collector Technology (L0018) | Lecture | 2 | 2 |
| Solar Power Generation (L0015) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Martin Kaltschmitt |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | With the completion of this module, students will be able to deal with technical foundations and current issues and problems in the field of solar energy and explain and evaulate these critically in consideration of the prior curriculum and current subject specific issues. In particular they can professionally describe the processes within a solar cell and explain the specific features of application of solar modules. Furthermore, they can provide an overview of the collector technology in solar thermal systems. |
| *Skills* | Students can apply the acquired theoretical foundations of exemplary energy systems using solar radiation. In this context, for example they can assess and evaluate potential and constraints of solar energy systems with respect to different geographical assumptions. They are able to dimension solar energy systems in consideration of technical aspects and given assumptions. Using module-comprehensive knowledge students can evalute the economic and ecologic conditions of these systems. They can select calculation methods within the radiation theory for these topics. |
| **Personal Competence** | |
| *Social Competence* | Students are able to discuss issues in the thematic fields in the renewable energy sector addressed within the module. |
| *Autonomy* | Students can independently exploit sources and acquire the particular knowledge about the subject area with respect to emphasis fo the lectures. Furthermore, with the assistance of lecturers, they can discrete use calculation methods for analysing and dimensioning solar energy systems. Based on this procedure they can concrete assess their specific learning level and can consequently define the further workflow. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 3 hours written exam |
| **Assignment for the Following Curricula** | Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory<br>Energy Systems: Specialisation Energy Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>Renewable Energies: Core Qualification: Compulsory<br>Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory |

| Course L0016: Energy Meteorology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Volker Matthias, Dr. Beate Geyer |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Introduction: radiation source Sun, Astronomical Foundations, Fundamentals of radiation<br>• Structure of the atmosphere<br>• Properties and laws of radiation<br>   ◦ Polarization<br>   ◦ Radiation quantities<br>   ◦ Planck's radiation law<br>   ◦ Wien's displacement law<br>   ◦ Stefan-Boltzmann law<br>   ◦ Kirchhoff's law<br>   ◦ Brightness temperature<br>   ◦ Absorption, reflection, transmission<br>• Radiation balance, global radiation, energy balance<br>• Atmospheric extinction<br>• Mie and Rayleigh scattering<br>• Radiative transfer<br>• Optical effects in the atmosphere<br>• Calculation of the sun and calculate radiation on inclined surfaces |
| **Literature** | • Helmut Kraus: Die Atmosphäre der Erde<br>• Hans Häckel: Meteorologie<br>• Grant W. Petty: A First Course in Atmosheric Radiation<br>• Martin Kaltschmitt, Wolfgang Streicher, Andreas Wiese: Renewable Energy<br>• Alexander Löw, Volker Matthias: Skript Optik Strahlung Fernerkundung |

| Course L0017: Energy Meteorology | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Beate Geyer |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0018: Collector Technology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Agis Papadopoulos |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Introduction: Energy demand and application of solar energy.<br>• Heat transfer in the solar thermal energy: conduction, convection, radiation.<br>• Collectors: Types, structure, efficiency, dimensioning, concentrated systems.<br>• Energy storage: Requirements, types.<br>• Passive solar energy: components and systems.<br>• Solar thermal low temperature systems: collector variants, construction, calculation.<br>• Solar thermal high temperature systems: Classification of solar power plants construction.<br>• Solar air conditioning. |
| **Literature** | • Vorlesungsskript.<br>• Kaltschmitt, Streicher und Wiese (Hrsg.). Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, 5. Auflage, Springer, 2013.<br>• Stieglitz und Heinzel .Thermische Solarenergie: Grundlagen, Technologie, Anwendungen. Springer, 2012.<br>• Von Böckh und Wetzel. Wärmeübertragung: Grundlagen und Praxis, Springer, 2011.<br>• Baehr und Stephan. Wärme- und Stoffübertragung. Springer, 2009.<br>• de Vos. Thermodynamics of solar energy conversion. Wiley-VCH, 2008.<br>• Mohr, Svoboda und Unger. Praxis solarthermischer Kraftwerke. Springer, 1999. |

| Course L0015: Solar Power Generation | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Alf Mews, Martin Schlecht, Roman Fritsches-Baguhl |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction<br>2. Primary energy and consumption, available solar energy<br>3. Physics of the ideal solar cell<br>4. Light absorption PN junction characteristic values of the solar cell efficiency<br>5. Physics of the real solar cell<br>6. Charge carrier recombination characteristics, junction layer recombination, equivalent circuit<br>7. Increasing the efficiency<br>8. Methods for increasing the quantum yield, and reduction of recombination<br>9. Straight and tandem structures<br>10. Hetero-junction, Schottky, electrochemical, MIS and SIS-cell tandem cell<br>11. Concentrator<br>12. Concentrator optics and tracking systems<br>13. Technology and properties: types of solar cells, manufacture, single crystal silicon and gallium arsenide, polycrystalline silicon, and silicon thin film cells, thin-film cells on carriers (amorphous silicon, CIS, electrochemical cells)<br>14. Modules<br>15. Circuits |
| **Literature** | • A. Götzberger, B. Voß, J. Knobloch: Sonnenenergie: Photovoltaik, Teubner Studienskripten, Stuttgart, 1995<br>• A. Götzberger: Sonnenenergie: Photovoltaik : Physik und Technologie der Solarzelle, Teubner Stuttgart, 1994<br>• H.-J. Lewerenz, H. Jungblut: Photovoltaik, Springer, Berlin, Heidelberg, New York, 1995<br>• A. Götzberger: Photovoltaic solar energy generation, Springer, Berlin, 2005<br>• C. Hu, R. M. White: Solar Cells, Mc Graw Hill, New York, 1983<br>• H.-G. Wagemann: Grundlagen der photovoltaischen Energiewandlung: Solarstrahlung, Halbleitereigenschaften und Solarzellenkonzepte, Teubner, Stuttgart, 1994<br>• R. J. van Overstraeten, R.P. Mertens: Physics, technology and use of photovoltaics, Adam Hilger Ltd, Bristol and Boston, 1986<br>• B. O. Seraphin: Solar energy conversion Topics of applied physics V 01 31, Springer, Berlin, Heidelberg, New York, 1995<br>• P. Würfel: Physics of Solar cells, Principles and new concepts, Wiley-VCH, Weinheim 2005<br>• U. Rindelhardt: Photovoltaische Stromversorgung, Teubner-Reihe Umwelt, Stuttgart 2001<br>• V. Quaschning: Regenerative Energiesysteme, Hanser, München, 2003<br>• G. Schmitz: Regenerative Energien, Ringvorlesung TU Hamburg-Harburg 1994/95, Institut für Energietechnik |

## Module M0513: System Aspects of Renewable Energies

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage (L0021) | Lecture | 2 | 2 |
| Energy Trading (L0019) | Lecture | 1 | 1 |
| Energy Trading (L0020) | Recitation Section (small) | 1 | 1 |
| Deep Geothermal Energy (L0025) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Martin Kaltschmitt |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Module: Technical Thermodynamics I<br><br>Module: Technical Thermodynamics II |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to describe the processes in energy trading and the design of energy markets and can critically evaluate them in relation to current subject specific problems. Furthermore, they are able to explain the basics of thermodynamics of electrochemical energy conversion in fuel cells and can establish and explain the relationship to different types of fuel cells and their respective structure. Students can compare this technology with other energy storage options. In addition, students can give an overview of the procedure and the energetic involvement of deep geothermal energy. |
| *Skills* | Students can apply the learned knowledge of storage systems for excessive energy to explain for various energy systems different approaches to ensure a secure energy supply. In particular, they can plan and calculate domestic, commercial and industrial heating equipment using energy storage systems in an energy-efficient way and can assess them in relation to complex power systems. In this context, students can assess the potential and limits of geothermal power plants and explain their operating mode.<br><br>Furthermore, the students are able to explain the procedures and strategies for marketing of energy and apply it in the context of other modules on renewable energy projects. In this context they can unassistedly carry out analysis and evaluations of energie markets and energy trades. |
| **Personal Competence** | |
| *Social Competence* | Students are able to discuss issues in the thematic fields in the renewable energy sector addressed within the module. |
| *Autonomy* | Students can independently exploit sources , acquire the particular knowledge about the subject area and transform it to new questions. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 3 hours written exam |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>Renewable Energies: Core Qualification: Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory |

| Course L0021: Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Fröba |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction to electrochemical energy conversion<br>2. Function and structure of electrolyte<br>3. Low-temperature fuel cell<br>◦ Types<br>◦ Thermodynamics of the PEM fuel cell<br>◦ Cooling and humidification strategy<br>4. High-temperature fuel cell<br>◦ The MCFC<br>◦ The SOFC<br>◦ Integration Strategies and partial reforming<br>5. Fuels<br>◦ Supply of fuel<br>◦ Reforming of natural gas and biogas<br>◦ Reforming of liquid hydrocarbons<br>6. Energetic Integration and control of fuel cell systems |
| **Literature** | • Hamann, C.; Vielstich, W.: Elektrochemie 3. Aufl.; Weinheim: Wiley - VCH, 2003 |

| Course L0019: Energy Trading | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Michael Sagorje, Dr. Sven Orlowski |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Basic concepts and tradable products in energy markets<br>• Primary energy markets<br>• Electricity Markets<br>• European Emissions Trading Scheme<br>• Influence of renewable energy<br>• Real options<br>• Risk management<br><br>Within the exercise the various tasks are actively discussed and applied to various cases of application. |
| **Literature** | |

| Course L0020: Energy Trading | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Michael Sagorje, Dr. Sven Orlowski |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0025: Deep Geothermal Energy | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Ben Norden |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction to the deep geothermal use<br>2. Geological Basics I<br>3. Geological Basics II<br>4. Geology and thermal aspects<br>5. Rock Physical Aspects<br>6. Geochemical aspects<br>7. Exploration of deep geothermal reservoirs<br>8. Drilling technologies, piping and expansion<br>9. Borehole Geophysics<br>10. Underground system characterization and reservoir engineering<br>11. Microbiology and Upper-day system components<br>12. Adapted investment concepts, cost and environmental aspect |
| **Literature** | • Dipippo, R.: Geothermal Power Plants: Principles, Applications, Case Studies and Environmental Impact. Butterworth Heinemann; 3rd revised edition. (29. Mai 2012)<br>• www.geo-energy.org<br>• Edenhofer et al. (eds): Renewable Energy Sources and Climate Change Mitigation; Special Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2012.<br>• Kaltschmitt et al. (eds): Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. Springer, 5. Aufl. 2013.<br>• Kaltschmitt et al. (eds): Energie aus Erdwärme. Spektrum Akademischer Verlag; Auflage: 1999 (3. September 2001)<br>• Huenges, E. (ed.): Geothermal Energy Systems: Exploration, Development, and Utilization. Wiley-VCH Verlag GmbH & Co. KGaA; Auflage: 1. Auflage (19. April 2010) |

## Module M0641: Steam Generators

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Steam Generators (L0213) | Lecture | 3 | 5 |
| Steam Generators (L0214) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Alfons Kather |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • "Technical Thermodynamics I and II"<br>• "Heat Transfer"<br>• "Fluid Mechanics"<br>• "Steam Power Plants" |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students know the thermodynamic base principles for steam generators and their types. They are able to describe the basic principles of steam generators and sketch the combustion and fuel supply aspects of fossil-fuelled power plants. They can perform thermal design calculations and conceive the water-steam side, as well as they are able to define the constructive details of the steam generator. The students can describe and evaluate the operational behaviour of steam generators and explain these in the context of related disciplines. |
| *Skills* | The students will be able, using detailed knowledge on the calculation, design, and construction of steam generators, linked with a wide theoretical and methodical foundation, to understand the main design and construction aspects of steam generators. Through problem definition and formalisation, modelling of processes, and training in the solution methodology for partial problems a good overview of this key component of the power plant will be obtained.<br><br>Within the framework of the exercise the students obtain the ability to draw the balances, and design the steam generator and its components. For this purpose small but close to lifelike tasks are solved, to highlight aspects of the design of steam generators. |
| **Personal Competence** | |
| *Social Competence* | Especially during the exercises the focus is placed on communication with the tutor. This animates the students to reflect on their existing knowledge and ask specific questions to further improve their understanding. |
| *Autonomy* | The students will be able to perform basic calculations covering aspects of the steam generator, with only the help of smaller clues, on their own. This way the theoretical and practical knowledge from the lecture is consolidated and the potential effects from different process schemata and boundary conditions are highlighted. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory**: No; **Bonus**: 5 %; **Form**: Excercises; **Description**: Den Studierenden wird eine kleine Aufgabe (in ca. 5 min lösbar) zur Vorlesung der Vorwoche gestellt. Die Antworten müssen üblicherweise als Freitext gegeben werden, aber auch Zeichnungen, Stichpunkte oder, in seltenen Fällen, Multiple Choice sind möglich. |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory<br>Energy Systems: Specialisation Energy Systems: Elective Compulsory<br>Energy Systems: Specialisation Marine Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory |

| Course L0213: Steam Generators | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 5 |
| **Workload in Hours** | Independent Study Time 108, Study Time in Lecture 42 |
| **Lecturer** | Prof. Alfons Kather |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Thermodynamics of steam<br>• Basic principles of steam generators<br>• Types of steam generators<br>• Fuels and combustion systems<br>• Coal pulverisers and coal drying<br>• Modes of operation<br>• Thermal analysis and design<br>• Fluid dynamics in steam generators<br>• Design of the water-steam side<br>• Construction aspects<br>• Stress analysis<br>• Feed water for steam generators<br>• Operating behaviour of steam Generators |
| **Literature** | • Dolezal, R.: Dampferzeugung. Springer-Verlag, 1985<br>• Thomas, H.J.: Thermische Kraftanlagen. Springer-Verlag, 1985<br>• Steinmüller-Taschenbuch: Dampferzeuger-Technik. Vulkan-Verlag, Essen, 1992<br>• Kakaç, Sadık: Boilers, Evaporators and Condensers. John Wiley & Sons, New York, 1991<br>• Stultz, S.C. and Kitto, J.B. (Ed.): Steam - its generation and use. 40th edition, The Babcock & Wilcox Company, Barberton, Ohio, USA, 1992 |

| Course L0214: Steam Generators | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Alfons Kather |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0721: Air Conditioning

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Air Conditioning (L0594) | Lecture | 3 | 5 |
| Air Conditioning (L0595) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Gerhard Schmitz |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students know the different kinds of air conditioning systems for buildings and mobile applications and how these systems are controlled. They are familiar with the change of state of humid air and are able to draw the state changes in a h1+x,x-diagram. They are able to calculate the minimum airflow needed for hygienic conditions in rooms and can choose suitable filters. They know the basic flow pattern in rooms and are able to calculate the air velocity in rooms with the help of simple methods. They know the principles to calculate an air duct network. They know the different possibilities to produce cold and are able to draw these processes into suitable thermodynamic diagrams. They know the criteria for the assessment of refrigerants. |
| *Skills* | Students are able to configure air condition systems for buildings and mobile applications. They are able to calculate an air duct network and have the ability to perform simple planning tasks, regarding natural heat sources and heat sinks. They can transfer research knowledge into practice. They are able to perform scientific work in the field of air conditioning. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss in small groups and develop an approach. |
| *Autonomy* | Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min |
| **Assignment for the Following Curricula** | Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory<br>Energy Systems: Specialisation Energy Systems: Elective Compulsory<br>Energy Systems: Specialisation Marine Engineering: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory |

| Course L0594: Air Conditioning | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 5 |
| **Workload in Hours** | Independent Study Time 108, Study Time in Lecture 42 |
| **Lecturer** | Prof. Gerhard Schmitz |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Overview<br><br>1.1 Kinds of air conditioning systems<br><br>1.2 Ventilating<br><br>1.3 Function of an air condition system<br><br>2. Thermodynamic processes<br><br>2.1 Psychrometric chart<br><br>2.2 Mixer preheater, heater<br><br>2.3 Cooler<br><br>2.4 Humidifier<br><br>2.5 Air conditioning process in a Psychrometric chart<br><br>2.6 Desiccant assisted air conditioning<br><br>3. Calculation of heating and cooling loads<br><br>3.1 Heating loads<br><br>3.2 Cooling loads<br><br>3.3 Calculation of inner cooling load<br><br>3.4 Calculation of outer cooling load<br><br>4. Ventilating systems<br><br>4.1 Fresh air demand<br><br>4.2 Air flow in rooms<br><br>4.3 Calculation of duct systems<br><br>4.4 Fans<br><br>4.5 Filters<br><br>5. Refrigeration systems<br><br>5.1. compression chillers<br><br>5.2Absorption chillers |
| **Literature** | • Schmitz, G.: Klimaanlagen, Skript zur Vorlesung<br>• VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013<br>• Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009<br>• Recknagel, H.; Sprenger, E.; Schrammek, E.-R.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013 |

| Course L0595: Air Conditioning | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Gerhard Schmitz |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1000: Combined Heat and Power and Combustion Technology

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Combined Heat and Power and Combustion Technology (L0216) | Lecture | 3 | 5 |
| Combined Heat and Power and Combustion Technology (L0220) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Alfons Kather |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • "Gas-Steam Power Plants"<br>• "Technical Thermodynamics I and II"<br>• "Heat Transfer"<br>• "Fluid Mechanics" |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students outline the thermodynamic and chemical fundamentals of combustion processes. From the knowledge of the characteristics and reaction kinetics of various fuels they can describe the behaviour of premixed flames and non-premixed flames, in order to describe the fundamentals of furnace design in gas-, oil- and coal combustion plant. The students are furthermore able to describe the formation of $NO_x$ and the primary $NO_x$ reduction measures, and evaluate the impact of regulations and allowable limit levels.<br><br>The students present the layout, design and operation of Combined Heat and Power plants and are in a position to compare with each other district heating plants with back-pressure steam turbine or condensing turbine with pressure-controlled extraction tapping, CHP plants with gas turbine or with combined steam and gas turbine, or even district heating plants with an internal combustion engine. They can explain and analyse aspects of combined heat, power and cooling (CCHP) and describe the layout of the key components needed. Through this specialised knowledge they are able to evaluate the ecological significance of district CHP generation, as well as its economics. |
| *Skills* | Using thermodynamic calculations and considering the reaction kinetics the students will be able to determine interdisciplinary correlations between thermodynamic and chemical processes during combustion. This then enables quantitative analysis of the combustion of gaseous, liquid and solid fuels and determination of the quantities and concentrations of the exhaust gases. In this module the first step toward the utilisation of an energy source (combustion) to provide usable energy (electricity and heat) is taught. An understanding of both procedures enables the students to holistically consider energy utilisation. Examples taken from the praxis, such as the CHP energy supply facility of the TUHH and the district heating network of Hamburg will be used, to highlight the potential from electricity generation plants with simultaneous heat extraction.<br><br>Within the framework of the exercises the students will first learn to calculate the energetic and mass balances of combustion processes. Moreover, the students will gain a deeper understanding of the combustion processes by the calculation of reaction kinetics. |
| **Personal Competence** | |
| *Social Competence* | Especially during the exercises the focus is placed on communication with the tutor. This animates the students to reflect on their existing knowledge and ask specific questions for improving further this knowledge level. |
| *Autonomy* | The students assisted by the tutors will be able to perform estimating calculations. In this manner the theoretical and practical knowledge from the lecture is consolidated and the potential impact of different process arrangements and boundary conditions highlighted. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory**: No; **Bonus**: 10 %; **Form**: Written elaboration; **Description**: Am Ende jeder Vorlesung wird schriftlich eine zu auswertende Kurzfrage (5-10 min) zu der Vorlesung der Vorwoche gestellt. In den Kurzfragen werden kleine Rechenaufgaben, Skizzen oder auch kleine Freitexte zur Beantwortung gestellt. |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory<br>Energy Systems: Specialisation Energy Systems: Elective Compulsory<br>Energy Systems: Specialisation Marine Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory |

| Course L0216: Combined Heat and Power and Combustion Technology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 5 |
| **Workload in Hours** | Independent Study Time 108, Study Time in Lecture 42 |
| **Lecturer** | Prof. Alfons Kather |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The subject area of "Combined Heat and Power" covers the following themes:<br>• Layout, design and operation of Combined Heat and Power plants<br>• District heating plants with back-pressure steam turbine and condensing turbine with pressure-controlled extraction tapping<br>• District heating plants with gas turbine<br>• District heating plants with combined steam and gas turbine<br>• District heating plants with motor engine<br>• Combined cooling heat and power (CCHP)<br>• Layout of the key components<br>• Regulatory framework and allowable limits<br>• Economic significance and calculation of the profitability of district CHP plant<br>whereas the subject of Combustion Technology includes:<br>• Thermodynamic and chemical fundamentals<br>• Fuels<br>• Reaction kinetics<br>• Premixed flames<br>• Non-premixed flames<br>• Combustion of gaseous fuels<br>• Combustion of liquid fuels<br>• Combustion of solid fuels<br>• Combustion Chamber design<br>• $NO_x$ reduction |
| **Literature** | Bezüglich des Themenbereichs "Kraft-Wärme-Kopplung":<br>• W. Piller, M. Rudolph: Kraft-Wärme-Kopplung, VWEW Verlag<br>• Kehlhofer, Kunze, Lehmann, Schüller: Handbuch Energie, Band 7, Technischer Verlag Resch<br>• W. Suttor: Praxis Kraft-Wärme-Kopplung, C.F. Müller Verlag<br>• K.W. Schmitz, G. Koch: Kraft-Wärme-Kopplung, VDI Verlag<br>• K.-H. Suttor, W. Suttor: Die KWK Fibel, Resch Verlag<br>und für die Grundlagen der "Verbrennungstechnik":<br>• J. Warnatz, U. Maas, R.W. Dibble; Technische Verbrennung: physikalisch-chemische Grundlagen, Modellbildung, Schadstoffentstehung. Springer, Berlin [u. a.], 2001 |

| Course L0220: Combined Heat and Power and Combustion Technology | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Alfons Kather |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0801: Water Resources and -Supply

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Chemistry of Drinking Water Treatment (L0311) | Lecture | 2 | 1 |
| Chemistry of Drinking Water Treatment (L0312) | Recitation Section (large) | 1 | 2 |
| Water Resource Management (L0402) | Lecture | 2 | 2 |
| Water Resource Management (L0403) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Mathias Ernst |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Knowledge of water management and the key processes involved in water treatment. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students will be able to outline key areas of conflict in water management, as well as their mutual dependence for sustainable water supply. They will understand relevant economic, environmental and social factors. Students will be able to explain and outline the organisational structures of water companies. They will be able to explain the available water treatment processes and the scope of their application. |
| *Skills* | Students will be able to assess complex problems in drinking water production and establish solutions involving water management and technical measures. They will be able to assess the evaluation methods that can be used for this. Students will be able to carry out chemical calculations for selected treatment processes and apply generally accepted technical rules and standards to these processes. |
| **Personal Competence** | |
| *Social Competence* | Working in a diverse group of specialists, students will be able to develop and document complex solutions for the management and treatment of drinking water. They will be able to take an appropriate professional position, for example representing user interests. They will be able to develop joint solutions in teams of diverse experts and present these solutions to others. |
| *Autonomy* | Students will be in a position to work on a subject independently and present on this subject. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min (chemistry) + presentation |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

| Course L0311: Chemistry of Drinking Water Treatment | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 2, Study Time in Lecture 28 |
| **Lecturer** | Dr. Klaus Johannsen |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The topic of this course is water chemistry with respect to drinking water treatment and water distribution<br><br>Major topics are solubility of gases, carbonic acid system and calcium carbonate,  blending, softening, redox processes, materials and legal requirements on drinking water treatment. Focus is put on generally accepted rules of technology (DVGW- and DIN-standards).<br><br>Special emphasis is put on calculations using realistic analysis data  (e.g. calculation of pH or calcium carbonate dissolution potential) in exercises. Students can get a feedback and gain extra points for exam by solving problems for homework.<br><br>Knowledge of drinking water treatment processes is vital for this lecture. Therefore the most important processes are explained coordinated with the course " Water resources management" in the beginning of the semester. |
| **Literature** | **MHW (rev. by Crittenden, J. et al.):** Water treatment principles and design. John Wiley & Sons, Hoboken, 2005.<br><br>**Stumm, W., Morgan, J.J.**: Aquatic chemistry. John Wiley & Sons, New York, 1996.<br><br>**DVGW (Hrsg.):** Wasseraufbereitung - Grundlagen und Verfahren. Oldenbourg Industrie Verlag, München, 2004.<br><br>**Jensen, J. N.**: A Problem Solving Approach to Aquatic Chemistry. John Wiley & Sons, Inc., New York, 2003. |

| Course L0312: Chemistry of Drinking Water Treatment | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Dr. Klaus Johannsen |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0402: Water Resource Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Mathias Ernst |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The lecture provides comprehensive knowledge on interaction of water ressource management and drinking water supply. Content overview:<br><br>• Current situation of global water resources<br><br>- User and Stakeholder conflicts<br><br>- Wasserressourcenmanagement in urbane Gebieten<br><br>- Rechtliche Aspekte, Organisationsformen Trinkwasserversorgungsunternehmen.<br><br>- Ökobilanzierung, Benchmarking in der Wasserversorgung |
| **Literature** | • Aktuelle UN World Water Development Reports<br>• Branchenbild der deutschen Wasserwirtschaft, VKU (2011)<br>• Aktuelle Artikel wissenschaftlicher Zeitschriften<br>• Ppt der Vorlesung |

| Course L0403: Water Resource Management | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Mathias Ernst |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0902: Wastewater Treatment and Air Pollution Abatement

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Biological Wastewater Treatment (L0517) | Lecture | 2 | 3 |
| Air Pollution Abatement (L0203) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Dr. Swantje Pietsch-Braune |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge of biology and chemistry<br><br>basic knowledge of solids process engineering and separation technology |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After successful completion of the module students are able to<br>• name and explain  biological processes for waste water treatment,<br>• characterize waste water and sewage sludge<br>• discuss legal regulations in the area of emissions and air quality<br>• classify off gas tretament processes and to define their area of application |
| *Skills* | Students are able to<br>• choose and design processs steps for the biological waste water treatment<br>• combine processes for cleaning of off-gases depending on the pollutants contained in the gases |
| **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** | 90 min |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory<br>Energy and Environmental Engineering: Specialisation Environmental Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory<br>Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Compulsory |

### Course L0517: Biological Wastewater Treatment

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Joachim Behrendt |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | Charaterisation of Wastewater<br>Metobolism of Microorganisms<br>Kinetic of mirobiotic processes<br>Calculation of bioreactor for wastewater treatment<br>Concepts of Wastewater treatment<br>Design of WWTP<br>Excursion to a WWTP<br>Biofilms<br>Biofim Reactors<br>Anaerobic Wastewater and sldge treatment<br>resources oriented sanitation technology<br>Future challenges of wastewater treatment |

| | |
|---|---|
| **Literature** | **Gujer, Willi**<br>Siedlungswasserwirtschaft : mit 84 Tabellen<br>ISBN: 3540343296 (Gb.) URL: http://www.gbv.de/dms/bs/toc/516261924.pdf URL: http://deposit.d-nb.de/cgi-bin/dokserv?id=2842122&prov=M&dok_var=1&dok_ext=htm<br>Berlin [u.a.] : Springer, 2007<br>TUB_HH_Katalog<br>**Henze, Mogens**<br>Wastewater treatment : biological and chemical processes<br>ISBN: 3540422285 (Pp.)<br>Berlin [u.a.] : Springer, 2002<br>TUB_HH_Katalog<br>**Imhoff, Karl** (Imhoff, Klaus R.;)<br>Taschenbuch der Stadtentwässerung : mit 10 Tafeln<br>ISBN: 3486263331 ((Gb.))<br>München [u.a.] : Oldenbourg, 1999<br>TUB_HH_Katalog<br>**Lange, Jörg** (Otterpohl, Ralf; Steger-Hartmann, Thomas;)<br>Abwasser : Handbuch zu einer zukunftsfähigen Wasserwirtschaft<br>ISBN: 3980350215 (kart.) URL: http://www.gbv.de/du/services/agi/52567E5D44DA0809C12570220050BF25/000000700334<br>Donaueschingen-Pfohren : Mall-Beton-Verl., 2000<br>TUB_HH_Katalog<br>**Mudrack, Klaus** (Kunst, Sabine;)<br>Biologie der Abwasserreinigung : 18 Tabellen<br>ISBN: 382741427X URL: http://www.gbv.de/du/services/agi/94B581161B6EC747C1256E3F005A8143/420000114903<br>Heidelberg [u.a.] : Spektrum, Akad. Verl., 2003<br>TUB_HH_Katalog<br>**Tchobanoglous, George** (Metcalf & Eddy, Inc., ;)<br>Wastewater engineering : treatment and reuse<br>ISBN: 0070418780 (alk. paper) ISBN: 0071122508 (ISE (*pbk))<br>Boston [u.a.] : McGraw-Hill, 2003<br>TUB_HH_Katalog<br>**Henze, Mogens**<br>Activated sludge models ASM1, ASM2, ASM2d and ASM3<br>ISBN: 1900222248<br>London : IWA Publ., 2002<br>TUB_HH_Katalog<br>**Kunz, Peter**<br>Umwelt-Bioverfahrenstechnik<br>Vieweg, 1992<br>**Bauhaus-Universität., Arbeitsgruppe Weiterbildendes Studium Wasser und Umwelt** (Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall, ;)<br>Abwasserbehandlung : Gewässerbelastung, Bemessungsgrundlagen, Mechanische Verfahren, Biologische Verfahren, Reststoffe aus der Abwasserbehandlung, Kleinkläranlagen<br>ISBN: 3860682725 URL: http://www.gbv.de/dms/weimar/toc/513989765_toc.pdf URL: http://www.gbv.de/dms/weimar/abs/513989765_abs.pdf<br>Weimar : Universitätsverl, 2006<br>TUB_HH_Katalog<br>**Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall**<br>DWA-Regelwerk<br>Hennef : DWA, 2004<br>TUB_HH_Katalog<br>**Wiesmann, Udo** (Choi, In Su; Dombrowski, Eva-Maria;)<br>Fundamentals of biological wastewater treatment<br>ISBN: 3527312196 (Gb.) URL: http://deposit.ddb.de/cgi-bin/dokserv?id=2774611&prov=M&dok_var=1&dok_ext=htm<br>Weinheim : WILEY-VCH, 2007<br>TUB_HH_Katalog |

| Course L0203: Air Pollution Abatement | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Swantje Pietsch-Braune |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | In the lecture methods for the reduction of emissions from industrial plants are treated. At the beginning a short survey of the different forms of air pollutants is given. In the second part physical principals for the removal of particulate and gaseous pollutants form flue gases are treated. Industrial applications of these principles are demonstrated with examples showing the removal of specific compounds, e.g. sulfur or mercury from flue gases of incinerators. |
| **Literature** | Handbook of air pollution prevention and control, Nicholas P. Cheremisinoff. - Amsterdam [u.a.] : Butterworth-Heinemann, 2002<br>Atmospheric pollution : history, science, and regulation, Mark Zachary Jacobson. - Cambridge [u.a.] : Cambridge Univ. Press, 2002<br>Air pollution control technology handbook, Karl B. Schnelle. - Boca Raton [u.a.] : CRC Press, c 2002<br>Air pollution, Jeremy Colls. - 2. ed. - London [u.a.] : Spon, 2002 |

## Module M0949: Rural Development and Resources Oriented Sanitation for different Climate Zones

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Rural Development and Resources Oriented Sanitation for different Climate Zones (L0942) | Seminar | 2 | 3 |
| Rural Development and Resources Oriented Sanitation for different Climate Zones (L0941) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Ralf Otterpohl |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge of the global situation with rising poverty, soil degradation, lack of water resources and sanitation |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can describe resources oriented wastewater systems mainly based on source control in detail. They can comment on techniques designed for reuse of water, nutrients and soil conditioners.<br><br>Students are able to discuss a wide range of proven approaches in Rural Development from and for many regions of the world. |
| *Skills* | Students are able to design low-tech/low-cost sanitation, rural water supply, rainwater harvesting systems, measures for the rehabilitation of top soil quality combined with food and water security. Students can consult on the basics of soil building through “Holisitc Planned Grazing” as developed by Allan Savory. |
| **Personal Competence** | |
| *Social Competence* | The students are able to develop a specific topic in a team and to work out milestones according to a given plan. |
| *Autonomy* | Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | During the course of the semester, the students work towards mile stones. The work includes presentations and papers. Detailed information will be provided at the beginning of the smester. |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Chemical and Bioprocess Engineering: Specialisation General Process Engineering: Elective Compulsory<br>Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Water: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Water: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

| Course L0942: Rural Development and Resources Oriented Sanitation for different Climate Zones | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Central part of this module is a group work on a subtopic of the lectures. The focus of these projects will be based on an interview with a target audience, practitioners or scientists.<br>• The group work is divided into several Milestones and Assignments. The outcome will be presented in a final presentation at the end of the semester. |
| **Literature** | • J. Lange, R. Otterpohl 2000: Abwasser - Handbuch zu einer zukunftsfähigen Abwasserwirtschaft. Mallbeton Verlag (TUHH Bibliothek)<br>• Winblad, Uno and Simpson-Hébert, Mayling 2004: Ecological Sanitation, EcoSanRes, Sweden (free download)<br>• Schober, Sabine: WTO/TUHH Award winning Terra Preta Toilet Design: http://youtu.be/w_R09cYq6ys |

| Course L0941: Rural Development and Resources Oriented Sanitation for different Climate Zones | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Living Soil - THE key element of Rural Development<br>• Participatory Approaches<br>• Rainwater Harvesting<br>• Ecological Sanitation Principles and practical examples<br>• Permaculture Principles of Rural Development<br>• Performance and Resilience of Organic Small Farms<br>• Going Further: The TUHH Toolbox for Rural Development<br>• EMAS Technologies, Low cost drinking water supply |
| **Literature** | • Miracle Water Village, India, Integrated Rainwater Harvesting, Water Efficiency, Reforestation and Sanitation: http://youtu.be/9hmkgn0nBgk<br>• Montgomery, David R. 2007: Dirt: The Erosion of Civilizations, University of California Press |

## Module M1125: Bioresources and Biorefineries

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Biorefinery Technology (L0895) | Lecture | 2 | 2 |
| Biorefinery Technologie (L0974) | Recitation Section (small) | 1 | 1 |
| Bioresource Management (L0892) | Lecture | 2 | 2 |
| Bioresource Management (L0893) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Dr. Ina Körner |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics on engineering;<br>Basics of waste and energy management |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can give on overview on principles and theories in the field's bioresource management and biorefinery technology and can explain specialized terms and technologies. |
| *Skills* | Students are capable of applying knowledge and know-how in the field's bioresource management and biorefinery technology in order to perform technical and regional-planning tasks. They are also able to discuss the links to waste management, energy management and biotechnology. |
| **Personal Competence** | |
| *Social Competence* | Students can work goal-oriented with others and communicate and document their interests and knowledge in acceptable way. |
| *Autonomy* | Students are able to solve independently, with the aid of pointers, practice-related tasks bearing in mind possible societal consequences. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | Chemical and Bioprocess Engineering: Specialisation Bioprocess Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory<br>Environmental Engineering: Specialisation Biotechnology: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Energy: Elective Compulsory |

| Course L0895: Biorefinery Technology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Ina Körner |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | The Europe 2020 strategy calls for bioeconomy as the key for smart and green growth of today. Biorefineries are the fundamental part on the way to convert the use of fossil-based society to bio-based society. For this reason, agriculture and forestry sectors are increasingly deliver bioresources. It is not only for their traditional applications in the food and feed sectors such as pulp or paper and construction material productions, but also to produce bioenergy and bio-based products such as bio-plastics. However although bioresources are renewable, they are considered as limited resources as well. The bioeconomy's limitation factor is the availability land on our world. In the context of the development of the bioeconomy, the sustainable and reliable supply of noon-food biomass feedstock is a critical success factor for the long-term perspective of bioenergy and other bio-based products production. Biorefineries are complex of technologies and process cascades using the available primary, secondary and tertiary bioresources to produce a multitude of products - a product mix from material and energy products.<br><br>The lecture gives an overview on biorefinery technology and shall contribute to promotion of international biorefinery developments.<br><br>Lectures:<br><br>• What is a biorefinery: Overview on basic organic substrates and processes which lead to material and energy products<br>• The way from a fossil based to a biobased economy in the 21st century<br>• The worlds most advanced biorefinery<br>• Presentation of various biorefinery systems and their products (e.g. lignocellulose biorefinery, green biorefinery, whole plant biorefinery, civilization biorefinery)<br>• Example projects (e.g. combination of anaerobic digestion and composting in practice; demonstration project in Hamburgs city quarter Jenfelder Au)<br><br>The lectures will be accompanied by technical tours. Optional it is also possible to visit more biorefinery lectures in the University of Hamburg (lectures in German only).<br><br>In the exercise students have the possibility to work in groups on a biorefinery project or to work on a student-specific task. |
| **Literature** | Biorefineries - Industrial Process and Products - Status Qua and Future directions by Kamm, Gruber and Kamm (2010); Wiley VCH, available on-line in TUHH-library<br><br>Powerpoint-Präsentations / selected Publications / further recommendations depending on the actual developments<br><br>Industrial Biorefineries and White Biorefinery, by Pandey, Höfer, Larroche, Taherzadeh, Nampoothiri (Eds.); (2014 book development in progress) |

| Course L0974: Biorefinery Technologie | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Ina Körner |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | 1. ) Selection of a topic within the thematic area "Biorefinery Technologie" from a given list or self-selected.<br><br>2.) Self-dependent recherches to the topic.<br><br>3.) Preparation of a written elaboration.<br><br>4.) Presentation of the results in the group. |
| **Literature** | Vom Thema abhängig. Eigene Recherchen nötig.<br><br>Depending on the topic. Own recheches necassary. |

| Course L0892: Bioresource Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Ina Körner |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | In the context of limited fossil resources, climate change mitigation and increasing population growth, Bioresources has a special role. They have to feed the population and in the same time they are important for material production such as pulp and paper or construction materials. Moreover they become more and more important in chemical industry and in energy provision as fossil substitution. Although Bioresources are renewable, they are also considered as limited resources. The availability of land on our planet is the main limitation factor. The sustainable and reliable supply of non-food biomass feedstock is a critical for successful and long term perspective on production of bioenergy and other bio-based products. As the consequence, the increasing competition and shortages continue to happen at the traditional sectors. On the other side, huge unused but potentials residue on waste and wastewater sector exist. Nowadays, a lot of activities to develop better processes, to create new bio-based products in order to become more efficient, the inclusion of secondary and tertiary bio-resources in the valorisation chain are going on.<br><br>The lecture deals with the current state-of-the-art of bioresource management. It shows deficits and potentials for improvement especially in the sector of utilization of organic residues for material and energy generation:<br><br>*Lectures on:*<br><br>• Bioresource generation and utilization including lost potentials today<br>• Basic biological, mechanical, physico-chemical and logistical processes<br>• The conflict of material vs. energy generation from wood / waste wood<br>• The basics of pulp & paper production including waste paper recycling<br>• The Pros and Cons from biogas and compost production<br><br>*Special lectures by invited guests from research and practice:*<br><br>• Pathways of waste organics on the example of Hamburg`s City Cleaning Company<br>• Utilization options of landscaping materials on the example of grass<br>• Increase of process efficiency of anaerobic digestions<br>• Decision support tools on the example of an municipality in Indonesia<br><br>*Optional: Technical visits* |
| **Literature** | Power-Point presentations in STUD-IP |

| Course L0893: Bioresource Management | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Ina Körner |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0540: Transport Processes

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Multiphase Flows (L0104) | Lecture | 2 | 2 |
| Reactor Design Using Local Transport Processes (L0105) | Project-/problem-based Learning | 2 | 2 |
| Heat & Mass Transfer in Process Engineering (L0103) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Michael Schlüter |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | All lectures from the undergraduate studies, especially mathematics, chemistry, thermodynamics, fluid mechanics, heat- and mass transfer. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to:<br>• describe transport processes in single- and multiphase flows and they know the analogy between heat- and mass transfer as well as the limits of this analogy.<br>• explain the main transport laws and their application as well as the limits of application.<br>• describe how transport coefficients for heat- and mass transfer can be derived experimentally.<br>• compare different multiphase reactors like trickle bed reactors, pipe reactors, stirring tanks and bubble column reactors.<br>• are known. The Students are able to perform mass and energy balances for different kind of reactors. Further more the industrial application of multiphase reactors for heat- and mass transfer are known. |
| *Skills* | The students are able to:<br>• optimize multiphase reactors by using mass- and energy balances,<br>• use transport processes for the design of technical processes,<br>• to choose a multiphase reactor for a specific application. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss in international teams in english and develop an approach under pressure of time. |
| *Autonomy* | Students are able to define independently tasks, to solve the problem "design of a multiphase reactor". The knowledge that s necessary is worked out by the students themselves on the basis of the existing knowledge from the lecture. The students are able to decide by themselves what kind of equation and model is applicable to their certain problem. They are able to organize their own team and to define priorities for different tasks. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 15 min Presentation + 90 min multiple choice written examen |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core Qualification: Compulsory<br>Energy and Environmental Engineering: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L0104: Multiphase Flows | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Schlüter |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Interfaces in MPF (boundary layers, surfactants)<br>• Hydrodynamics & pressure drop in Film Flows<br>• Hydrodynamics & pressure drop in Gas-Liquid Pipe Flows<br>• Hydrodynamics & pressure drop in Bubbly Flows<br>• Mass Transfer in Film Flows<br>• Mass Transfer in Gas-Liquid Pipe Flows<br>• Mass Transfer in Bubbly Flows<br>• Reactive mass Transfer in Multiphase Flows<br>• Film Flow: Application Trickle Bed Reactors<br>• Pipe Flow: Application Turbular Reactors<br>• Bubbly Flow: Application Bubble Column Reactors |
| **Literature** | Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.<br>Clift, R.; Grace, J.R.; Weber, M.E.: Bubbles, Drops and Particles, Academic Press, New York, 1978.<br>Fan, L.-S.; Tsuchiya, K.: Bubble Wake Dynamics in Liquids and Liquid-Solid Suspensions, Butterworth-Heinemann Series in Chemical Engineering, Boston, USA, 1990.<br>Hewitt, G.F.; Delhaye, J.M.; Zuber, N. (Ed.): Multiphase Science and Technology. Hemisphere Publishing Corp, Vol. 1/1982 bis Vol. 6/1992.<br>Kolev, N.I.: Multiphase flow dynamics. Springer, Vol. 1 and 2, 2002.<br>Levy, S.: Two-Phase Flow in Complex Systems. Verlag John Wiley & Sons, Inc, 1999.<br>Crowe, C.T.: Multiphase Flows with Droplets and Particles. CRC Press, Boca Raton, Fla, 1998. |

| Course L0105: Reactor Design Using Local Transport Processes | |
|---|---|
| **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 Schlüter |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | In this Problem-Based Learning unit the students have to design a multiphase reactor for a fast chemical reaction concerning optimal hydrodynamic conditions of the multiphase flow.<br><br>The four students in each team have to:<br><br>• collect and discuss material properties and equations for design from the literature,<br>• calculate the optimal hydrodynamic design,<br>• check the plausibility of the results critically,<br>• write an exposé with the results.<br><br>This exposé will be used as basis for the discussion within the oral group examen of each team. |
| **Literature** | see actual literature list in StudIP with recent published papers |

| Course L0103: Heat & Mass Transfer in Process Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Schlüter |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Introduction - Transport Processes in Chemical Engineering<br>• Molecular Heat- and Mass Transfer: Applications of Fourier's and Fick's Law<br>• Convective Heat and Mass Transfer: Applications in Process Engineering<br>• Unsteady State Transport Processes: Cooling & Drying<br>• Transport at fluidic Interfaces: Two Film, Penetration, Surface Renewal<br>• Transport Laws & Balance Equations  with turbulence, sinks and sources<br>• Experimental Determination of Transport Coefficients<br>• Design and Scale Up of Reactors for Heat- and Mass Transfer<br>• Reactive Mass Transfer<br>• Processes with Phase Changes – Evaporization and Condensation<br>• Radiative Heat Transfer - Fundamentals<br>• Radiative Heat Transfer - Solar Energy |
| **Literature** | 1. Baehr, Stephan: Heat and Mass Transfer, Wiley 2002.<br>2. Bird, Stewart, Lightfood: Transport Phenomena, Springer, 2000.<br>3. John H. Lienhard: A Heat Transfer Textbook,  Phlogiston Press, Cambridge Massachusetts, 2008.<br>4. Myers: Analytical Methods in Conduction Heat Transfer, McGraw-Hill, 1971.<br>5. Incropera, De Witt: Fundamentals of Heat and Mass Transfer, Wiley, 2002.<br>6. Beek, Muttzall: Transport Phenomena, Wiley, 1983.<br>7. Crank: The Mathematics of Diffusion, Oxford, 1995.<br>8. Madhusudana: Thermal Contact Conductance, Springer, 1996.<br>9. Treybal: Mass-Transfer-Operation, McGraw-Hill, 1987. |

## Module M0542: Fluid Mechanics in Process Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Applications of Fluid Mechanics in Process Engineering (L0106) | Recitation Section (large) | 2 | 2 |
| Fluid Mechanics II (L0001) | Lecture | 2 | 4 |

| | |
|---|---|
| **Module Responsible** | Prof. Michael Schlüter |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Mathematics I-III<br>• Fundamentals in Fluid Mechanics<br>• Technical Thermodynamics I-II<br>• Heat- and Mass Transfer |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are able to describe different applications of fluid mechanics in Process Engineering, Bioprocess Engineering, Energy- and Environmental Process Engineering and Renewable Energies. They are able to use the fundamentals of fluid mechanics for calculations of certain engineering problems. The students are able to estimate if a problem can be solved with an analytical solution and what kind of alternative possibilities are available (e.g. self-similarity in an example of free jets, empirical solutions in an example with the Forchheimer equation, numerical methods in an example of Large Eddy Simulation. |
| *Skills* | Students are able to use the governing equations of Fluid Dynamics for the design of technical processes. Especially they are able to formulate momentum and mass balances to optimize the hydrodynamics of technical processes. They are able to transform a verbal formulated message into an abstract formal procedure. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss a given problem in small groups and to develop an approach. |
| *Autonomy* | Students are able to define independently tasks for problems related to fluid mechanics. They are able to work out the knowledge that is necessary to solve the problem by themselves on the basis of the existing knowledge from the lecture. |
| **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** | Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Energy and Environmental Engineering: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L0106: Applications of Fluid Mechanics in Process Engineering | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Schlüter |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The Exercise-Lecture will bridge the gap between the theoretical content from the lecture and practical calculations. For this aim a special exercise is calculated at the blackboard that shows how the theoretical knowledge from the lecture can be used to solve real problems in Process Engineering. |
| **Literature** | 1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.<br>2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.<br>3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.<br>4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.<br>5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.<br>6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006.<br>7. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008.<br>8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007<br>9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009.<br>10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.<br>11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008.<br>12. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.<br>13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.<br>14. White, F.: Fluid Mechanics, Mcgraw-Hill, ISBN-10: 0071311211, ISBN-13: 978-0071311212, 2011. |

| Course L0001: Fluid Mechanics II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Schlüter |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Differential equations for momentum-, heat and mass transfer<br>• Examples for simplifications of the Navier-Stokes Equations<br>• Unsteady momentum transfer<br>• Free shear layer, turbulence and free jets<br>• Flow around particles - Solids Process Engineering<br>• Coupling of momentum and heat transfer - Thermal Process Engineering<br>• Rheology – Bioprocess Engineering<br>• Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering<br>• Flow threw porous structures - heterogeneous catalysis<br>• Pumps and turbines - Energy- and Environmental Process Engineering<br>• Wind- and Wave-Turbines - Renewable Energy<br>• Introduction into Computational Fluid Dynamics |
| **Literature** | 1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.<br>2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.<br>3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.<br>4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.<br>5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.<br>6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006.<br>7. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008.<br>8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007<br>9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009.<br>10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.<br>11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008.<br>12. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.<br>13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882. |

## Module M0619: Waste Treatment Technologies

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Waste and Environmental Chemistry (L0328) | Practical Course | 2 | 2 |
| Biological Waste Treatment (L0318) | Project-/problem-based Learning | 3 | 4 |

| | |
|---|---|
| **Module Responsible** | Prof. Kerstin Kuchta |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | chemical and biological basics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The module aims possess knowledge concerning the planning of biological waste treatment plants. Students are able to explain the design and layout of anaerobic and aerobic waste treatment plants in detail, describe different techniques for waste gas treatment plants for biological waste treatment plants and explain different methods for waste analytics. |
| *Skills* | The students are able to discuss the compilation of design and layout of plants. They can critically evaluate techniques and quality control measurements. The students can recherché and evaluate literature and date connected to the tasks given in der module and plan additional tests. They are capable of reflecting and evaluating findings in the group. |
| **Personal Competence** | |
| *Social Competence* | Students can participate in subject-specific and interdisciplinary discussions, develop cooperated solutions and defend their own work results in front of others and promote the scientific development in front of colleagues. Furthermore, they can give and accept professional constructive criticism. |
| *Autonomy* | Students can independently tap knowledge from literature, business or test reports and transform it to the course projects. They are capable, in consultation with supervisors as well as in the interim presentation, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>Yes / None / Subject theoretical and practical work / |
| **Examination** | Presentation |
| **Examination duration and scale** | Elaboration and Presentation (15-25 minutes in groups) |
| **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>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Energy and Environmental Engineering: Specialisation Environmental Engineering: Elective Compulsory<br>Environmental Engineering: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>Joint European Master in Environmental Studies - Cities and Sustainability: Specialisation Energy: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory |

| Course L0328: Waste and Environmental Chemistry | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | The participants are divided into groups. Each group prepares a transcript on the experiment performed, which is then used as basis for discussing the results and to evaluate the performance of the group and the individual student.<br><br>In some experiments the test procedure and the results are presented in seminar form, accompanied by discussion and results evaluation.<br><br>Experiments ar e.g.<br><br>Screening  and particle size determination<br><br>Fos/Tac<br><br>AAS<br><br>Chalorific value |
| **Literature** | Scripte |

| Course L0318: Biological Waste Treatment | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | 1. Introduction<br>2. biological basics<br>3. determination process specific material characterization<br>4. aerobic degradation ( Composting, stabilization)<br>5. anaerobic degradation (Biogas production, fermentation)<br>6. Technical layout and process design<br>7. Flue gas treatment<br>8. Plant design practical phase |
| **Literature** | |

## Module M0742: Thermal Energy Systems

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Thermal Engergy Systems (L0023) | Lecture | 3 | 5 |
| Thermal Engergy Systems (L0024) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Gerhard Schmitz |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students know the different energy conversion stages and the difference between efficiency and annual efficiency. They have increased knowledge in heat and mass transfer, especially in regard to buildings and mobile applications. They are familiar with German energy saving code and other technical relevant rules. They know to differ different heating systems in the domestic and industrial area and how to control such heating systems. They are able to model a furnace and to calculate the transient temperatures in a furnace. They have the basic knowledge of emission formations in the flames of small burners  and how to conduct the flue gases into the atmosphere. They are able to model thermodynamic systems with object oriented languages. |
| *Skills* | Students are able to calculate the heating demand for different heating systems and to choose the suitable components. They are able to calculate a pipeline network and have the ability to perform simple planning tasks, regarding solar energy. They can write Modelica programs and can transfer research knowledge into practice. They are able to perform scientific work in the field of thermal engineering. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss in small groups and develop an approach. |
| *Autonomy* | Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Energy and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory<br>Energy Systems: Specialisation Energy Systems: Compulsory<br>Energy Systems: Specialisation Marine Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>Product Development, Materials and Production: Core Qualification: Elective Compulsory<br>Renewable Energies: Core Qualification: Compulsory<br>Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory |

| Course L0023: Thermal Engergy Systems | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 5 |
| **Workload in Hours** | Independent Study Time 108, Study Time in Lecture 42 |
| **Lecturer** | Prof. Gerhard Schmitz |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | 1. Introduction<br><br>2. Fundamentals of Thermal Engineering 2.1 Heat Conduction 2.2 Convection 2.3 Radiation 2.4 Heat transition 2.5 Combustion parameters 2.6 Electrical heating 2.7 Water vapor transport<br><br>3. Heating Systems 3.1 Warm water heating systems 3.2 Warm water supply 3.3 piping calculation 3.4 boilers, heat pumps, solar collectors 3.5 Air heating systems 3.6 radiative heating systems<br><br>4. Thermal traetment systems 4.1 Industrial furnaces 4.2 Melting furnaces 4.3 Drying plants 4.4 Emission control 4.5 Chimney calculation 4.6 Energy measuring<br><br>5. Laws and standards 5.1 Buildings 5.2 Industrial plants |
| **Literature** | • Schmitz, G.: Klimaanlagen, Skript zur Vorlesung<br>• VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013<br>• Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009<br>• Recknagel, H.; Sprenger, E.; Schrammek, E.-R.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013 |

| Course L0024: Thermal Engergy Systems | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Gerhard Schmitz |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1037: Steam Turbines in Energy, Environmental and Power Train Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Steam turbines in energy, environmental and Power Train Engineering (L1286) | Lecture | 3 | 5 |
| Steam turbines in energy, environmental and Power Train Engineering (L1287) | Recitation Section (small) | 1 | 1 |

**Module Responsible:** Prof. Alfons Kather

**Admission Requirements:** None

**Recommended Previous Knowledge**

- "Gas and Steam Power Plants"
- "Technical Thermodynamics I & II"
- "Fluid Mechanics"

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

**Professional Competence**

*Knowledge*

After successful completion of the module the students must be in a position to:

- name and identify the various parts and constructive groups of steam turbines
- describe and explain the key operating conditions for the application of steam turbines
- classify different construction types and differentiate among steam turbines according to size and operating ranges
- describe the thermodynamic processes and the constructive and operational repercussions resulting from the latter
- calculate thermodynamically a turbine stage and a stage assembly
- calculate or estimate and further evaluate sections of the turbine
- outline diagrams describing the operating range and the constructive characteristics
- investigate the constructive aspects and develop from the thermodynamic requirements the required construction characteristics
- discuss and argue on the operation characteristics of different turbine types
- evaluate thermodynamically the integration of different turbine designs in heat cycles.

*Skills*

In the module the students learn the fundamental approaches and methods for the design and operational evaluation of complex plant, and gain in particular confidence in seeking optimisations. They specifically:

- obtain the ability to analyse the potential of various energy sources that can be utilised thermodynamically, from the energetic-economic and technical viewpoints
- can evaluate the performance and technical limitations in using various energy sources, for supplying base load and balancing reserve power to the electricity grid
- on the basis of the impact of power plant operation on the integrity of components, can describe the precautionary principles for damage prevention
- can describe the key requirements for the Management and Design of Thermal Power Plants, based on the overriding demands imposed by various legislative frameworks.

**Personal Competence**

*Social Competence*

In the module the students learn:

- to work together with others whilst seeking a solution
- to assist each other in problem solving
- to conduct discussions
- to present work results
- to work respectfully within the team.

*Autonomy*

In the module the students learn the independent working of a complex theme whilst considering various aspects. They also learn how to combine independent functions in a system.

The students become the ability to gain independently knowledge and transfer it also to new problem solving.

**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 and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory
International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory
Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory
Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory

| Course L1286: Steam turbines in energy, environmental and Power Train Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 5 |
| **Workload in Hours** | Independent Study Time 108, Study Time in Lecture 42 |
| **Lecturer** | Dr. Christian Scharfetter |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction<br>• Construction Aspects of a Steam Turbine<br>• Energy Conversion in a Steam Turbine<br>• Construction Types of Steam Turbines<br>• Behaviour of Steam Turbines<br>• Sealing Systems for Steam Turbines<br>• Axial Thrust<br>• Regulation of Steam Turbines<br>• Stiffness Calculation of the Blades<br>• Blade and Rotor Oscillations<br>• Fundamentals of a Safe Steam Turbine Operation<br>• Application in Conventional and Renewable Power Stations<br>• Connection to thermal and electrical energy networks, interfaces<br>• Conventional and regenerative power plant concepts, drive technology<br>• Analysis of the global energy supply market<br>• Applications in conventional and regenerative power plants<br>• Different power plant concepts and their influence on the steam turbine (engine and gas turbine power plants with waste heat utilization, geothermal energy, solar thermal energy, biomass, biogas, waste incineration).<br>• Classic combined heat and power generation as a combined product of the manufacturing industry<br>• Impact of change in the energy market, operating profiles<br>• Applications in drive technology<br>• Operating and maintenance concepts<br><br>The lecture will be deepened by means of examples, tasks and two excursions |
| **Literature** | • Traupel, W.: Thermische Turbomaschinen. Berlin u. a., Springer (TUB HH: Signatur MSI-105)<br>• Menny, K.: Strömungsmaschinen: hydraulische und thermische Kraft- und Arbeitsmaschinen. Ausgabe: 5. Wiesbaden, Teubner, 2006 (TUB HH: Signatur MSI-121)<br>• Bohl, W.: Aufbau und Wirkungsweise. Ausgabe 6. Würzburg, Vogel, 1994 (TUB HH: Signatur MSI-109)<br>• Bohl, W.: Berechnung und Konstruktion. Ausgabe 6. Aufl. Würzburg, Vogel, 1999 (TUB HH: Signatur MSI-110) |

| Course L1287: Steam turbines in energy, environmental and Power Train Engineering | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Christian Scharfetter |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

# Specialization II. Information Technology

## Module M0551: Pattern Recognition and Data Compression

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Pattern Recognition and Data Compression (L0128) | Lecture | 4 | 6 |

| | |
|---|---|
| **Module Responsible** | Prof. Rolf-Rainer Grigat |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Linear algebra (including PCA, unitary transforms), stochastics and statistics, binary arithmetics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can name the basic concepts of pattern recognition and data compression.<br><br>Students are able to discuss logical connections between the concepts covered in the course and to explain them by means of examples. |
| *Skills* | Students can apply statistical methods to classification problems in pattern recognition and to prediction in data compression. On a sound theoretical and methodical basis they can analyze characteristic value assignments and classifications and describe data compression and video signal coding. They are able to use highly sophisticated methods and processes of the subject area. Students are capable of assessing different solution approaches in multidimensional decision-making areas. |
| **Personal Competence** | |
| *Social Competence* | k.A. |
| *Autonomy* | Students are capable of identifying problems independently and of solving them scientifically, using the methods they have learnt. |
| **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>Electrical Engineering: Specialisation Information and Communication Systems: 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>International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory<br>International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory<br>Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory<br>Mechatronics: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory |

| Course L0128: Pattern Recognition and Data Compression | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 4 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Lecturer** | Prof. Rolf-Rainer Grigat |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | Structure of a pattern recognition system, statistical decision theory, classification based on statistical models, polynomial regression, dimension reduction, multilayer perceptron regression, radial basis functions, support vector machines, unsupervised learning and clustering, algorithm-independent machine learning, mixture models and EM, adaptive basis function models and boosting, Markov random fields<br><br>Information, entropy, redundancy, mutual information, Markov processes, basic coding schemes (code length, run length coding, prefix-free codes), entropy coding (Huffman, arithmetic coding), dictionary coding (LZ77/Deflate/LZMA2, LZ78/LZW), prediction, DPCM, CALIC, quantization (scalar and vector quantization), transform coding, prediction, decorrelation (DPCM, DCT, hybrid DCT, JPEG, JPEG-LS), motion estimation, subband coding, wavelets, HEVC (H.265,MPEG-H) |
| **Literature** | Schürmann: Pattern Classification, Wiley 1996<br>Murphy, Machine Learning, MIT Press, 2012<br>Barber, Bayesian Reasoning and Machine Learning, Cambridge, 2012<br>Duda, Hart, Stork: Pattern Classification, Wiley, 2001<br>Bishop: Pattern Recognition and Machine Learning, Springer 2006<br><br>Salomon, Data Compression, the Complete Reference, Springer, 2000<br>Sayood, Introduction to Data Compression, Morgan Kaufmann, 2006<br>Ohm, Multimedia Communication Technology, Springer, 2004<br>Solari, Digital video and audio compression, McGraw-Hill, 1997<br>Tekalp, Digital Video Processing, Prentice Hall, 1995 |

## Module M0758: Application Security

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Application Security (L0726) | Lecture | 3 | 3 |
| Application Security (L0729) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Dieter Gollmann |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Familiarity with Information security, fundamentals of cryptography, Web protocols and the architecture of the Web |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can name current approaches for securing selected applications, in particular of web applications |
| *Skills* | Students are capable of<br>• performing a security analysis<br>• developing security solutions for distributed applications<br>• recognizing the limitations of existing standard solutions |
| **Personal Competence** | |
| *Social Competence* | Students are capable of appreciating the impact of security problems on those affected and of the potential responsibilities for their resolution. |
| *Autonomy* | Students are capable of acquiring knowledge independently from professional publications, technical standards, and other sources, and are capable of applying newly acquired knowledge to new problems. |
| **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 minutes |
| **Assignment for the Following Curricula** | Computer Science: Specialisation Computer and Software Engineering: Elective Compulsory<br>Information and Communication Systems: Specialisation Communication Systems, Focus Software: Elective Compulsory<br>Information and Communication Systems: Specialisation Secure and Dependable IT Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory |

### Course L0726: Application Security

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Dieter Gollmann |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Email security<br>• Web Services security<br>• Security in Web applications<br>• Access control<br>• Trust Management<br>• Trusted Computing<br>• Digital Rights Management<br>• Security Solutions for selected applications |
| **Literature** | Webseiten der OMG, W3C, OASIS, WS-Security, OECD, TCG<br><br>D. Gollmann: Computer Security, 3rd edition, Wiley (2011)<br><br>R. Anderson: Security Engineering, 2nd edition, Wiley (2008)<br><br>U. Lang: CORBA Security, Artech House, 2002 |

| Course L0729: Application Security | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Gollmann |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0627: Machine Learning and Data Mining

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Machine Learning and Data Mining (L0340) | Lecture | 2 | 4 |
| Machine Learning and Data Mining (L0510) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | NN |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Calculus<br>• Stochastics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can explain the difference between instance-based and model-based learning approaches, and they can enumerate basic machine learning technique for each of the two basic approaches, either on the basis of static data, or on the basis of incrementally incoming data . For dealing with uncertainty, students can describe suitable representation formalisms, and they explain how axioms, features, parameters, or structures used in these formalisms can be learned automatically with different algorithms. Students are also able to sketch different clustering techniques. They depict how the performance of learned classifiers can be improved by ensemble learning, and they can summarize how this influences computational learning theory. Algorithms for reinforcement learning can also be explained by students. |
| *Skills* | Student derive decision trees and, in turn, propositional rule sets from simple and static data tables and are able to name and explain basic optimization techniques. They present and apply the basic idea of first-order inductive leaning. Students apply the BME, MAP, ML, and EM algorithms for learning parameters of Bayesian networks and compare the different algorithms. They also know how to carry out Gaussian mixture learning. They can contrast kNN classifiers, neural networks, and support vector machines, and name their basic application areas and algorithmic properties. Students can describe basic clustering techniques and explain the basic components of those techniques. Students compare related machine learning techniques, e.g., k-means clustering and nearest neighbor classification. They can distinguish various ensemble learning techniques and compare the different goals of those techniques. |
| **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** | 90 minutes |
| **Assignment for the Following Curricula** | Computer Science: Specialisation Intelligence Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory<br>Mechatronics: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Numerics and Computer Science: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory |

| Course L0340: Machine Learning and Data Mining | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Rainer Marrone |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Decision trees<br>• First-order inductive learning<br>• Incremental learning: Version spaces<br>• Uncertainty<br>• Bayesian networks<br>• Learning parameters of Bayesian networks<br>BME, MAP, ML, EM algorithm<br>• Learning structures of Bayesian networks<br>• Gaussian Mixture Models<br>• kNN classifier, neural network classifier, support vector machine (SVM) classifier<br>• Clustering<br>Distance measures, k-means clustering, nearest neighbor clustering<br>• Kernel Density Estimation<br>• Ensemble Learning<br>• Reinforcement Learning<br>• Computational Learning Theory |
| **Literature** | 1. Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russel, Peter Norvig, Prentice Hall, 2010, Chapters 13, 14, 18-21<br>2. Machine Learning: A Probabilistic Perspective, Kevin Murphy, MIT Press 2012 |

| Course L0510: Machine Learning and Data Mining | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Rainer Marrone |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1336: Soft Computing - Introduction to Machine Learning

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Soft Computing - Introduction to Machine Learning (L1869) | Lecture | 4 | 6 |

| | |
|---|---|
| **Module Responsible** | Prof. Karl-Heinz Zimmermann |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Bachelor in Computer Science.<br><br>Basics in higher mathematics are inevitable, like calculus, linear algebra, graph theory, and optimization. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to formalize, compute, and analyze belief networks, alignments of sequences, hidden Markov models, phylogenetic tree models, classical regression and clustering methods, neural networks, and fuzzy controllers. |
| *Skills* | Students can apply the relevant algorithms and determine their complexity, and they can make use of the statistics language R. |
| **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 new knowledge from newer literature and to associate the acquired knowledge to other fields. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Oral exam |
| **Examination duration and scale** | 25 min |
| **Assignment for the Following Curricula** | Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory<br>Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory<br>Mechatronics: Specialisation System Design: Elective Compulsory<br>Mechatronics: Technical Complementary Course: 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 L1869: Soft Computing - Introduction to Machine Learning

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 4 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Lecturer** | Prof. Karl-Heinz Zimmermann, Dr. Mehwish Saleemi |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | Students are able to formalize, compute, and analyze belief networks, alignments of sequences, hidden Markov models, phylogenetic tree models, neural networks, and fuzzy controllers. In particular, inference and learning in belief networks are important topics that the students should be able to master.<br>Students can apply the relevant algorithms and determine their complexity, and they can make use of the statistics language R. |
| **Literature** | 1. David Barber, Bayes Reasoning and Machine Learning, Cambridge Univ. Press, Cambridge, 2012.<br>2. Volker Claus, Stochastische Automaten, Teubner, Stuttgart, 1971.<br>3. Ernst Klement, Radko Mesiar, Endre Pap, Triangular Norms, Kluwer, Dordrecht, 2000.<br>4. Timo Koski, John M. Noble, Bayesian Networks, Wiley, New York, 2009.<br>5. Dimitris Margaritis, Learning Bayesian Network Model Structure from Data, PhD thesis, Carnegie Mellon University, Pittsburgh, 2003.<br>6. Hidetoshi Nishimori, Statistical Physics of Spin Glasses and Information Processing, Oxford Univ. Press, London, 2001.<br>7. James R. Norris, Markov Chains, Cambridge Univ. Press, Cambridge, 1996.<br>8. Maria Rizzo, Statistical Computing with R, Chapman & Hall/CRC, Boca Raton, 2008.<br>9. Peter Sprites, Clark Glymour, Richard Scheines, Causation, Prediction, and Search, Springer, New York, 1993.<br>10. Raul Royas, Neural Networks, Springer, Berlin, 1996.<br>11. Lior Pachter, Bernd Sturmfels, Algebraic Statistics for Computational Biology, Cambridge Univ. Press, Cambridge, 2005.<br>12. David A. Sprecher, From Algebra to Computational Algorithms, Docent Press, Boston, 2017.<br>13. Karl-Heinz Zimmermann, Algebraic Statistics, TubDok, Hamburg, 2016. |

## Module M0836: Communication Networks

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Selected Topics of Communication Networks (L0899) | Project-/problem-based Learning | 2 | 2 |
| Communication Networks (L0897) | Lecture | 2 | 2 |
| Communication Networks Excercise (L0898) | Project-/problem-based Learning | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Andreas Timm-Giel |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Fundamental stochastics<br>• Basic understanding of computer networks and/or communication technologies is beneficial |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to describe the principles and structures of communication networks in detail. They can explain the formal description methods of communication networks and their protocols. They are able to explain how current and complex communication networks work and describe the current research in these examples. |
| *Skills* | Students are able to evaluate the performance of communication networks using the learned methods. They are able to work out problems themselves and apply the learned methods. They can apply what they have learned autonomously on further and new communication networks. |
| **Personal Competence** | |
| *Social Competence* | Students are able to define tasks themselves in small teams and solve these problems together using the learned methods. They can present the obtained results. They are able to discuss and critically analyse the solutions. |
| *Autonomy* | Students are able to obtain the necessary expert knowledge for understanding the functionality and performance capabilities of new communication networks independently. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Presentation |
| **Examination duration and scale** | 1.5 hours colloquium with three students, therefore about 30 min per student. Topics of the colloquium are the posters from the previous poster session and the topics of the module. |
| **Assignment for the Following Curricula** | Electrical Engineering: Specialisation Information and Communication Systems: Elective Compulsory<br>Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory<br>Computational Science and Engineering: Specialisation I. Computer Science: Elective Compulsory<br>Information and Communication Systems: Specialisation Secure and Dependable IT Systems, Focus Networks: Elective Compulsory<br>Information and Communication Systems: Specialisation Communication Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory<br>Mechatronics: Technical Complementary Course: Elective Compulsory<br>Microelectronics and Microsystems: Specialisation Communication and Signal Processing: Elective Compulsory |

### Course L0899: Selected Topics of Communication Networks

| | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Andreas Timm-Giel |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Example networks selected by the students will be researched on in a PBL course by the students in groups and will be presented in a poster session at the end of the term. |
| **Literature** | • see lecture |

| Course L0897: Communication Networks | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Andreas Timm-Giel, Dr.-Ing. Koojana Kuladinithi |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | • Skript des Instituts für Kommunikationsnetze<br>• Tannenbaum, Computernetzwerke, Pearson-Studium<br><br>Further literature is announced at the beginning of the lecture. |

| Course L0898: Communication Networks Excercise | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Andreas Timm-Giel |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Part of the content of the lecture Communication Networks are reflected in computing tasks in groups, others are motivated and addressed in the form of a PBL exercise. |
| **Literature** | • announced during lecture |

## Module M0550: Digital Image Analysis

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Digital Image Analysis (L0126) | Lecture | 4 | 6 |

| | |
|---|---|
| **Module Responsible** | Prof. Rolf-Rainer Grigat |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | System theory of one-dimensional signals (convolution and correlation, sampling theory, interpolation and decimation, Fourier transform, linear time-invariant systems), linear algebra (Eigenvalue decomposition, SVD), basic stochastics and statistics (expectation values, influence of sample size, correlation and covariance, normal distribution and its parameters), basics of Matlab, basics in optics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can<br><br>• Describe imaging processes<br>• Depict the physics of sensorics<br>• Explain linear and non-linear filtering of signals<br>• Establish interdisciplinary connections in the subject area and arrange them in their context<br>• Interpret effects of the most important classes of imaging sensors and displays using mathematical methods and physical models. |
| *Skills* | Students are able to<br><br>• Use highly sophisticated methods and procedures of the subject area<br>• Identify problems and develop and implement creative solutions.<br><br>Students can solve simple arithmetical problems relating to the specification and design of image processing and image analysis systems.<br><br>Students are able to assess different solution approaches in multidimensional decision-making areas.<br><br>Students can undertake a prototypical analysis of processes in Matlab. |
| **Personal Competence** | |
| *Social Competence* | k.A. |
| *Autonomy* | Students can solve image analysis tasks independently using the relevant literature. |
| **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 II: Intelligence Engineering: Elective Compulsory<br>Electrical Engineering: Specialisation Information and Communication Systems: Elective Compulsory<br>Electrical Engineering: Specialisation Medical Technology: 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>International Management and Engineering: Specialisation II. Information Technology: 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 L0126: Digital Image Analysis | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 4 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Lecturer** | Prof. Rolf-Rainer Grigat |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Image representation, definition of images and volume data sets, illumination, radiometry, multispectral imaging, reflectivities, shape from shading<br>• Perception of luminance and color, color spaces and transforms, color matching functions, human visual system, color appearance models<br>• imaging sensors (CMOS, CCD, HDR, X-ray, IR), sensor characterization(EMVA1288), lenses and optics<br>• spatio-temporal sampling (interpolation, decimation, aliasing, leakage, moiré, flicker, apertures)<br>• features (filters, edge detection, morphology, invariance, statistical features, texture)<br>• optical flow ( variational methods, quadratic optimization, Euler-Lagrange equations)<br>• segmentation (distance, region growing, cluster analysis, active contours, level sets, energy minimization and graph cuts)<br>• registration (distance and similarity, variational calculus, iterative closest points) |
| **Literature** | Bredies/Lorenz, Mathematische Bildverarbeitung, Vieweg, 2011<br>Wedel/Cremers, Stereo Scene Flow for 3D Motion Analysis, Springer 2011<br>Handels, Medizinische Bildverarbeitung, Vieweg, 2000<br>Pratt, Digital Image Processing, Wiley, 2001<br>Jain, Fundamentals of Digital Image Processing, Prentice Hall, 1989 |

## Module M0629: Intelligent Autonomous Agents and Cognitive Robotics

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Intelligent Autonomous Agents and Cognitive Robotics (L0341) | Lecture | 2 | 4 |
| Intelligent Autonomous Agents and Cognitive Robotics (L0512) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Rainer Marrone |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Vectors, matrices, Calculus |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can explain the agent abstraction, define intelligence in terms of rational behavior, and give details about agent design (goals, utilities, environments). They can describe the main features of environments. The notion of adversarial agent cooperation can be discussed in terms of decision problems and algorithms for solving these problems. For dealing with uncertainty in real-world scenarios, students can summarize how Bayesian networks can be employed as a knowledge representation and reasoning formalism in static and dynamic settings. In addition, students can define decision making procedures in simple and sequential settings, with and with complete access to the state of the environment. In this context, students can describe techniques for solving (partially observable) Markov decision problems, and they can recall techniques for measuring the value of information. Students can identify techniques for simultaneous localization and mapping, and can explain planning techniques for achieving desired states. Students can explain coordination problems and decision making in a multi-agent setting in term of different types of equilibria, social choice functions, voting protocol, and mechanism design techniques. |
| *Skills* | Students can select an appropriate agent architecture for concrete agent application scenarios. For simplified agent application students can derive decision trees and apply basic optimization techniques. For those applications they can also create Bayesian networks/dynamic Bayesian networks and apply bayesian reasoning for simple queries. Students can also name and apply different sampling techniques for simplified agent scenarios. For simple and complex decision making students can compute the best action or policies for concrete settings. In multi-agent situations students will apply techniques for finding different equilibria states,e.g., Nash equilibria. For multi-agent decision making students will apply different voting protocols and compare and explain the results. |
| **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 varaints 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** | 90 minutes |
| **Assignment for the Following Curricula** | Computer Science: Specialisation II: Intelligence Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory<br>Mechatronics: Technical Complementary Course: 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>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 L0341: Intelligent Autonomous Agents and Cognitive Robotics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Rainer Marrone |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Definition of agents, rational behavior, goals, utilities, environment types<br>• Adversarial agent cooperation:<br>Agents with complete access to the state(s) of the environment, games, Minimax algorithm, alpha-beta pruning, elements of chance<br>• Uncertainty:<br>Motivation: agents with no direct access to the state(s) of the environment, probabilities, conditional probabilities, product rule, Bayes rule, full joint probability distribution, marginalization, summing out, answering queries, complexity, independence assumptions, naive Bayes, conditional independence assumptions<br>• Bayesian networks:<br>Syntax and semantics of Bayesian networks, answering queries revised (inference by enumeration), typical-case complexity, pragmatics: reasoning from effect (that can be perceived by an agent) to cause (that cannot be directly perceived).<br>• Probabilistic reasoning over time:<br>Environmental state may change even without the agent performing actions, dynamic Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation, special cases: hidden Markov models, Kalman filters, Exact inferences and approximations<br>• Decision making under uncertainty:<br>Simple decisions: utility theory, multivariate utility functions, dominance, decision networks, value of informatio<br>Complex decisions: sequential decision problems, value iteration, policy iteration, MDPs<br>Decision-theoretic agents: POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks<br>• Simultaneous Localization and Mapping<br>• Planning<br>• Game theory (Golden Balls: Split or Share)<br>Decisions with multiple agents, Nash equilibrium, Bayes-Nash equilibrium<br>• Social Choice<br>Voting protocols, preferences, paradoxes, Arrow's Theorem,<br>• Mechanism Design<br>Fundamentals, dominant strategy implementation, Revelation Principle, Gibbard-Satterthwaite Impossibility Theorem, Direct mechanisms, incentive compatibility, strategy-proofness, Vickrey-Groves-Clarke mechanisms, expected externality mechanisms, participation constraints, individual rationality, budget balancedness, bilateral trade, Myerson-Satterthwaite Theorem |
| **Literature** | 1. Artificial Intelligence: A Modern Approach (Third Edition), Stuart Russell, Peter Norvig, Prentice Hall, 2010, Chapters 2-5, 10-11, 13-17<br>2. Probabilistic Robotics, Thrun, S., Burgard, W., Fox, D. MIT Press 2005<br>3. Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Yoav Shoham, Kevin Leyton-Brown, Cambridge University Press, 2009 |

| Course L0512: Intelligent Autonomous Agents and Cognitive Robotics | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Rainer Marrone |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0676: Digital Communications

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Digital Communications (L0444) | Lecture | 2 | 3 |
| Digital Communications (L0445) | Recitation Section (large) | 2 | 2 |
| Laboratory Digital Communications (L0646) | Practical Course | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Gerhard Bauch |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Mathematics 1-3<br>• Signals and Systems<br>• Fundamentals of Communications and Random Processes |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are able to understand, compare and design modern digital information transmission schemes. They are familiar with the properties of linear and non-linear digital modulation methods. They can describe distortions caused by transmission channels and design and evaluate detectors including channel estimation and equalization. They know the principles of single carrier transmission and multi-carrier transmission as well as the fundamentals of basic multiple access schemes. |
| *Skills* | The students are able to design and analyse a digital information transmission scheme including multiple access. They are able to choose a digital modulation scheme taking into account transmission rate, required bandwidth, error probability, and further signal properties. They can design an appropriate detector including channel estimation and equalization taking into account performance and complexity properties of suboptimum solutions. They are able to set parameters of a single carrier or multi carrier transmission scheme and trade the properties of both approaches against each other. |
| **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** | **Compulsory** Yes; **Bonus** None; **Form** Written elaboration; **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | Electrical Engineering: Core Qualification: Compulsory<br>Computational Science and Engineering: Specialisation II. Engineering Science: Elective Compulsory<br>Information and Communication Systems: Specialisation Communication Systems: Compulsory<br>Information and Communication Systems: Specialisation Secure and Dependable IT Systems, Focus Networks: Elective Compulsory<br>International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory<br>International Management and Engineering: Specialisation II. Electrical Engineering: Elective Compulsory<br>Microelectronics and Microsystems: Core Qualification: Elective Compulsory |

| Course L0444: Digital Communications | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Gerhard Bauch |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | • Digital modulation methods<br>• Coherent and non-coherent detection<br>• Channel estimation and equalization<br>• Single-Carrier- and multi carrier transmission schemes, multiple access schemes (TDMA, FDMA, CDMA, OFDM) |
| **Literature** | K. Kammeyer: Nachrichtenübertragung, Teubner<br>P.A. Höher: Grundlagen der digitalen Informationsübertragung, Teubner.<br>J.G. Proakis, M. Salehi: Digital Communications. McGraw-Hill.<br>S. Haykin: Communication Systems. Wiley<br>R.G. Gallager: Principles of Digital Communication. Cambridge<br>A. Goldsmith: Wireless Communication. Cambridge.<br>D. Tse, P. Viswanath: Fundamentals of Wireless Communication. Cambridge. |

| Course L0445: Digital Communications | |
|---|---|
| **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** | DE/EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0646: Laboratory Digital Communications | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Gerhard Bauch |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | - DSL transmission<br>- Random processes<br>- Digital data transmission |
| **Literature** | K. Kammeyer: Nachrichtenübertragung, Teubner<br>P.A. Höher: Grundlagen der digitalen Informationsübertragung, Teubner.<br>J.G. Proakis, M. Salehi: Digital Communications. McGraw-Hill.<br>S. Haykin: Communication Systems. Wiley<br>R.G. Gallager: Principles of Digital Communication. Cambridge<br>A. Goldsmith: Wireless Communication. Cambridge.<br>D. Tse, P. Viswanath: Fundamentals of Wireless Communication. Cambridge. |

## Module M0753: Software Verification

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Software Verification (L0629) | Lecture | 2 | 3 |
| Software Verification (L0630) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Sibylle Schupp |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Automata theory and formal languages<br>• Computational logic<br>• Object-oriented programming, algorithms, and data structures<br>• Functional programming or procedural programming<br>• Concurrency |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students apply the major verification techniques in model checking and deductive verification. They explain in formal terms syntax and semantics of the underlying logics, and assess the expressivity of different logics as well as their limitations. They classify formal properties of software systems. They find flaws in formal arguments, arising from modeling artifacts or underspecification. |
| *Skills* | Students formulate provable properties of a software system in a formal language. They develop logic-based models that properly abstract from the software under verification and, where necessary, adapt model or property. They construct proofs and property checks by hand or using tools for model checking or deductive verification, and reflect on the scope of the results. Presented with a verification problem in natural language, they select the appropriate verification technique and justify their choice. |
| **Personal Competence** | |
| *Social Competence* | Students discuss relevant topics in class. They defend their solutions orally. They communicate in English. |
| *Autonomy* | Using accompanying on-line material for self study, students can assess their level of knowledge continuously and adjust it appropriately. Working on exercise problems, they receive additional feedback. Within limits, they can set their own learning goals. Upon successful completion, students can identify and precisely formulate new problems in academic or applied research in the field of software verification. Within this field, they can conduct independent studies to acquire the necessary competencies and compile their findings in academic reports. They can devise plans to arrive at new solutions or assess existing ones. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes · **Bonus** 15 % · **Form** Excercises · **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | Computer Science: Specialisation I. Computer and Software Engineering: Elective Compulsory<br>Computational Science and Engineering: Specialisation I. Computer Science: Elective Compulsory<br>Information and Communication Systems: Specialisation Communication Systems, Focus Software: Elective Compulsory<br>Information and Communication Systems: Specialisation Secure and Dependable IT Systems: Compulsory<br>International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory |

| Course L0629: Software Verification | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Sibylle Schupp |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Syntax and semantics of logic-based systems<br>• Deductive verification<br>  ◦ Specification<br>  ◦ Proof obligations<br>  ◦ Program properties<br>  ◦ Automated vs. interactive theorem proving<br>• Model checking<br>  ◦ Foundations<br>  ◦ Property languages<br>  ◦ Tool support<br>• Timed automata<br>• Recent developments of verification techniques and applications |
| **Literature** | • C. Baier and J-P. Katoen, Principles of Model Checking, MIT Press 2007.<br>• M. Huth and M. Bryan, Logic in Computer Science. Modelling and Reasoning about Systems, 2nd Edition, 2004.<br>• Selected Research Papers |

| Course L0630: Software Verification | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Sibylle Schupp |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0733: Software Analysis

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Software Analysis (L0631) | Lecture | 2 | 3 |
| Software Analysis (L0632) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Sibylle Schupp |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Basic knowledge of software-engineering activities<br>• Discrete algebraic structures<br>• Object-oriented programming, algorithms, and data structures<br>• Functional programming or Procedural programming |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students apply the major approaches to data-flow analysis, control-flow analysis, and type-based analysis, along with their classification schemes, and employ abstract interpretation. They explain the standard forms of internal representations and models, including their mathematical structure and properties, and evaluate their suitability for a particular analysis. They explain and categorize the major analysis algorithms. They distinguish precise solutions from approximative approaches, and show termination and soundness properties. |
| *Skills* | Presented with an analytical task for a software artifact, students select appropriate approaches from software analysis, and justify their choice. They design suitable representations by modifying standard representations. They develop customized analyses and devise them as safe overapproximations. They formulate analyses in a formal way and construct arguments for their correctness, behavior, and precision. |
| **Personal Competence** | |
| *Social Competence* | Students discuss relevant topics in class. They defend their solutions orally. They communicate in English. |
| *Autonomy* | Using accompanying on-line material for self study, students can assess their level of knowledge continuously and adjust it appropriately. Working on exercise problems, they receive additional feedback. Within limits, they can set their own learning goals. Upon successful completion, students can identify and precisely formulate new problems in academic or applied research in the field of software analysis. Within this field, they can conduct independent studies to acquire the necessary competencies and compile their findings in academic reports. They can devise plans to arrive at new solutions or assess existing ones. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Subject theoretical and practical work |
| **Examination duration and scale** | software artifacts/mathematical write-ups; short presentation |
| **Assignment for the Following Curricula** | Information and Communication Systems: Specialisation Communication Systems, Focus Software: Elective Compulsory<br>Information and Communication Systems: Specialisation Secure and Dependable IT Systems, Focus Software and Signal Processing: Elective Compulsory<br>International Management and Engineering: Specialisation II. Information Technology: Elective Compulsory |

| Course L0631: Software Analysis | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Sibylle Schupp |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Modeling: Control-Flow Modeling, Data Dependences, Intermediate Languages)<br>• Classical Bit-Vector Analyses (Reaching Definition, Very Busy Expressions, Liveness, Available Expressions, May/Must, Forward/Backward)<br>• Monotone Frameworks (Lattices, Transfer Functions, Ascending Chain Condition, Distributivity, Constant Propagation)<br>• Theory of Data-Flow Analysis (Tarski's Fixed Point Theorem, Data-Flow Equations, MFP Solution, MOP Solution, Worklist Algorithm)<br>• Non-Classical Data-Flow Analyses<br>• Abstract Interpretation (Galois Connections, Approximating Fixed Points, Construction Techniques)<br>• Type Systems (Type Derivation, Inference Trees, Algorithm W, Unification)<br>• Recent Developments of Analysis Techniques and Applications |
| **Literature** | • Flemming Nielsen, Hanne Nielsen, and Chris Hankin. Principles of Program Analysis. Springer, 2nd. ed. 2005.<br>• Uday Khedker, Amitabha Sanyal, and Bageshri Karkara. Data Flow Analysis: Theory and Practice. CRC Press, 2009.<br>• Benjamin Pierce, Types and Programming Languages, MIT Press.<br>• Selected research papers |

| Course L0632: Software Analysis | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Sibylle Schupp |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Specialization II. Logistics

### 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**<br>Yes / None / Participation in excursions<br>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>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>Schieck, Arno: Internationale Logistik: Objekte, Prozesse und Infrastrukturen grenzüberschreitender Güterströme, München, 2009<br>BLOECH, J., IHDE, G. B. (1997) Vahlens Großes Logistiklexikon, München, Verlag C.H. Beck<br>IHDE, G. B. (1991) Transport, Verkehr, Logistik, München, Verlag Franz Vahlen, 2. völlig überarbeitete und erweiterte Auflage<br>NUHN, H., HESSE, M. (2006) Verkehrsgeographie, Paderborn, München, Wien, Zürich, Verlage Ferdinand Schöningh<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>Schieck, Arno: Internationale Logistik: Objekte, Prozesse und Infrastrukturen grenzüberschreitender Güterströme, München, 2009 |

## Module M1089: Integrated Maintenance and Spare Part Logistics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Spare Part Logistics (L1403) | Lecture | 1 | 2 |
| Maintenance Logistics (L1401) | Lecture | 2 | 2 |
| Exercises to Integrated Maintenance and Spare Part Logistics (L1405) | Recitation Section (small) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Kathrin Fischer |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge of logistical processes |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can explain basic concepts of maintenance and spare parts logistics and distinguish between them.<br>• Students can explain key approaches and concepts of maintenance and spare parts logistics, locate them in a theoretical context and present practical applications. |
| *Skills* | • Students can plan and evaluate processes, techniques and organizational forms in the field of maintenance and spare parts logistics.<br>• Students can apply planning methods in maintenance and spare parts logistics to practical examples.<br>• Students can develop and apply key performance indicator systems and carry out current status analyses. |
| **Personal Competence** | |
| *Social Competence* | • Students can present and argue their own expert opinions and work results in front of teachers and other students in an appropriate manner.<br>• Students can achieve accurate work results as members of a team. |
| *Autonomy* | • Students can access specialist knowledge independently and transfer the knowledge acquired to new 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** | 2 hours |
| **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 |

| Course L1403: Spare Part Logistics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Ingo Martens |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Introduction: Logistical spare parts management, factors influencing need for spare parts, spare logistics requireents, integration of spare parts logistics and maintenance logistics.<br>• Methoda: Analysis of spare parts stocks, diffentiation of spare parts strategy, forecasting need for spare parts, process chains<br>• Planning: preliminary planning, concept planning and realisation, planning instruments and tools.<br>• Practical examples for: optimization of spare parts centers, optimization of international spare parts distribution, performance-based logistics, new business models in spare parts logistics. |
| **Literature** | Scripts and text documents to be handed out during the course. |

| Course L1401: Maintenance Logistics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Ingo Martens |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Introduction: developments and trends in integrated maintenance and spare parts logistics, components of integrated maintenance, the terms maintenance and maintenance logistics, need for action and the “maintenance dilemma,” maintenance planning measures.<br>• Basics of integrated maintenance: maintenance technology, organisational structures and workflows, maintenance controlling, integration of employees and management.<br>• Knowledge-based business management and maintenance: Production and maintenance, condition knowledge and diagnosis, business management strategy, management, motivation and success.<br>• Target and key performance indicator systems: developing target systems, performance indicator requirements, performance indicator analysis, strengths and weaknesses analysis, potential analysis, performance indicator models, monitoring (IH Cockpit)<br>• Maintenance methods: make or buy versus outsourcing, total productive maintenance, differentiating between logistics strategies.<br>• Maintenance planning: concept planning and realization, concept planning tasks and steps, supplementing planning basics, technology and organisation sub-concepts, overall concept of integrated maintenance and spare parts logistics.<br>• Practical examples, including for: energy-efficient asset management, maintenance strategies in highly automated goods distribution centers, remote diagnosis and service management in wind energy plants, value stream analysis in maintenance. |
| **Literature** | Skripte und Textdokumente, die während der Vorlesung herausgegeben werden.<br><br>Scripts and text documents to be handed out during the course. |

| Course L1405: Exercises to Integrated Maintenance and Spare Part Logistics | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Ingo Martens |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | |
| **Literature** | Es wird die in den Vorlesungen "Instandhaltungdslogistik" und "Ersatzteillogistik" verwendete Literatur empfohlen. |

## Module M1132: Maritime Transport

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Maritime Transport (L0063) | Lecture | 2 | 3 |
| Maritime Transport (L0064) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Carlos Jahn |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are able to...<br>• present the actors involved in the maritime transport chain with regard to their typical tasks;<br>• name common cargo types in shipping and classify cargo to the corresponding categories;<br>• explain operating forms in maritime shipping, transport options and management in transport networks;<br>• weigh the advantages and disadvantages of the various modes of hinterland transport and apply them in practice;<br>• present relevant factors for the location planning of ports and seaport terminals and discuss them in a problem-oriented way;<br>• estimate the potential of digitisation in maritime shipping. |
| *Skills* | The students are able to...<br>• determine the mode of transport, actors and functions of the actors in the maritime supply chain;<br>• identify possible cost drivers in a transport chain and recommend appropriate proposals for cost reduction;<br>• record, map and systematically analyse material and information flows of a maritime logistics chain, identify possible problems and recommend solutions;<br>• perform risk assessments of human disruptions to the supply chain;<br>• analyse accidents in the field of maritime logistics and evaluating their relevance in everyday life;<br>• deal with current research topics in the field of maritime logistics in a differentiated way;<br>• apply different process modelling methods in a hitherto unknown field of activity and to work out the respective advantages. |
| **Personal Competence** | |
| *Social Competence* | The students are able to...<br>• discuss and organise extensive work packages in groups;<br>• document and present the elaborated results. |
| *Autonomy* | The students are capable to...<br>• research and select technical literature, including standards and guidelines;<br>• submit own shares in an extensive written elaboration in small groups in due time. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** No; **Bonus** 15 %; **Form** Subject theoretical and practical work; **Description** Teilnahme an einem Planspiel und anschließende schriftliche Ausarbeitung |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 minutes |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>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>Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory |

| Course L0063: Maritime Transport | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Carlos Jahn |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The general tasks of maritime logistics include the planning, design, implementation and control of material and information flows in the logistics chain ship - port - hinterland. This includes technology assessment, selection, dimensioning and implementation as well as the operation of technologies.<br><br>The aim of the course is to provide students with knowledge of maritime transport and the actors involved in the maritime transport chain. Typical problem areas and tasks will be dealt with, taking into account the economic development. Thus, classical problems as well as current developments and trends in the field of maritime logistics are considered.<br><br>In the lecture, the components of the maritime logistics chain and the actors involved will be examined and risk assessments of human disturbances on the supply chain will be developed. In addition, students learn to estimate the potential of digitisation in maritime shipping, especially with regard to the monitoring of ships. Further content of the lecture is the different modes of transport in the hinterland, which students can evaluate after completion of the course regarding their advantages and disadvantages. |
| **Literature** | • Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005.<br>• Schönknecht, Axel. Maritime Containerlogistik: Leistungsvergleich von Containerschiffen in intermodalen Transportketten. Berlin Heidelberg: Springer-Verlag, 2009.<br>• Stopford, Martin. Maritime Economics Routledge, 2009 |

| Course L0064: Maritime Transport | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Carlos Jahn |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The exercise lesson bases on the haptic management game MARITIME. MARITIME focuses on providing knowledge about structures and processes in a maritime transport network. Furthermore, the management game systematically provides process management methodology and also promotes personal skills of the participants. |
| **Literature** | • Stopford, Martin. Maritime Economics Routledge, 2009<br>• Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005.<br>• Schönknecht, Axel. Maritime Containerlogistik: Leistungsvergleich von Containerschiffen in intermodalen Transportketten. Berlin Heidelberg: Springer-Verlag, 2009. |

## Module M0977: Construction Logistics and Project Management

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Construction Logistics (L1163) | Lecture | 1 | 2 |
| Construction Logistics (L1164) | Recitation Section (small) | 1 | 2 |
| Project Development and Management (L1161) | Lecture | 1 | 1 |
| Project Development and Management (L1162) | Project-/problem-based Learning | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Heike Flämig |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can...<br>• give definitions of the main terms of construction logistics and project development and management<br>• name advantages and disadvantages of internal or external construction logistics<br>• explain characteristics of products, demand and production of construction objects and their consequences for construction specific supply chains<br>• differentiate constructions logistics from other logistics systems |
| *Skills* | Students can...<br>• carry out project life cycle assessments<br>• apply methods and instruments of construction logistics<br>• apply methods and instruments of project development and management<br>• apply methods and instruments of conflict management<br>• design supply and waste removal concepts for a construction project |
| **Personal Competence** | |
| *Social Competence* | Students can...<br>• hold presentations in and for groups<br>• apply methods of conflict solving skills in group work and case studies |
| *Autonomy* | Students can...<br>• solve problems by holistic, systemic and flow oriented thinking<br>• improve their creativity, negotiation skills, conflict and crises solution skills by applying methods of moderation in case studies |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Two written papers with presentations |
| **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>Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>International Management and Engineering: Specialisation II. Civil Engineering: Elective Compulsory<br>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 |

| Course L1163: Construction Logistics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Heike Flämig |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The lecture gives deeper insight how important logistics are as a competetive factor for construction projects and which issues are to be adressed.<br><br>The following toppics are covered:<br><br>• competetive factor logistics<br>• the concept of systems, planning and coordination of logistics<br>• material, equipment and reverse logistics<br>• IT in construction logistics<br>• elements of the planning model of construction logistics and their connections<br>• flow oriented logistics systems for construction projects<br>• logistics concepts for ready to use construction projects (especially procurement and waste removel logistics)<br>• best practice examples (construction logistics Potsdamer Platz, recent case study of the region)<br><br>Contents of the lecture are deepened in special exercises. |
| **Literature** | Flämig, Heike: Produktionslogistik in Stadtregionen. In: Forschungsverbund Ökologische Mobilität (Hrsg.) Forschungsbericht Bd. 15.2. Wuppertal 2000.<br><br>Krauss, Siri: Die Baulogistik in der schlüsselfertigen Ausführung, Bauwerk Verlag GmbH Berlin 2005.<br><br>Lipsmeier, Klaus: Abfallkennzahlen für Neubauleistungen im Hochbau : Verlag Forum für Abfallwirtschaft und Altlasten, 2004.<br><br>Schmidt, Norbert: Wettbewerbsfaktor Baulogistik. Neue Wertschöpfungspotenziale in der Baustoffversorgung. In: Klaus, Peter: Edition Logistik. Band 6. Deutscher Verkehrs-Verlag. Hamburg 2003.<br><br>Seemann, Y.F. (2007): Logistikkoordination als Organisationseinheit bei der Bauausführung Wissenschaftsverlag Mainz in Aachen, Aachen. (Mitteilungen aus dem Fachgebiet Baubetrieb und Bauwirtschaft (Hrsg. Kuhne, V.): Heft 20) |

| Course L1164: Construction Logistics | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Heike Flämig |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1161: Project Development and Management | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Heike Flämig, Dr. Anton Worobei |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Within the lecture, the main aspects of project development and management are tought:<br><br>• Terms and definitions of project management<br>• Advantages and disadvantages of different ways of project handling<br>• organization, information, coordination and documentation<br>• cost and fincance management in projects<br>• time- and capacity management in projects<br>• specific methods and instruments for successful team work<br><br>Contents of the lecture are deepened in special exercises. |
| **Literature** | Projektmanagement-Fachmann. Band 1 und Band 2. RKW-Verlag, Eschborn, 2004. |

| Course L1162: Project Development and Management | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Heike Flämig, Dr. Anton Worobei |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1133: Port Logistics

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Port Logistics (L0686) | Lecture | 2 | 3 |
| Port Logistics (L1473) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Carlos Jahn |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Th<br><br>After completing the module, students can...<br><br>• reflect on the development of seaports (in terms of the functions of the ports and the corresponding terminals, as well as the relevant operator models) and place them in their historical context;<br>• explain and evaluate different types of seaport terminals and their specific characteristics (cargo, transhipment technologies, logistic functional areas);<br>• analyze common planning tasks (e.g. berth planning, stowage planning, yard planning) at seaport terminals and develop suitable approaches (in terms of methods and tools) to solve these planning tasks;<br>• identify future developments and trends regarding the planning and control of innovative seaport terminals and discuss them in a problem-oriented manner. |
| *Skills* | After completing the module, students will be able to...<br><br>• recognize functional areas in ports and seaport terminals;<br>• define and evaluate suitable operating systems for container terminals;<br>• perform static calculations with regard to given boundary conditions, e.g. required capacity (parking spaces, equipment requirements, quay wall length, port access) on selected terminal types;<br>• reliably estimate which boundary conditions influence common logistics indicators in the static planning of selected terminal types and to what extent. |
| **Personal Competence** | |
| *Social Competence* | After completing the module, students can...<br><br>• transfer the acquired knowledge to further questions of port logistics;<br>• discuss and successfully organize extensive task packages in small groups;<br>• in small groups, document work results in writing in an understandable form and present them to an appropriate extent. |
| *Autonomy* | After completing the module, the students are able to...<br><br>• research and select specialist literature, including standards, guidelines and journal papers, and to develop the contents independently;<br>• submit own parts in an extensive written elaboration in small groups in due time and to present them jointly within a fixed time frame. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>No / 15 % / Written elaboration |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 minutes |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>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>Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory<br>Naval Architecture and Ocean Engineering: Core Qualification: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Maritime Technology: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory |

| Course L0686: Port Logistics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Carlos Jahn |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Port Logistics deals with the planning, control, execution and monitoring of material flows and the associated information flows in the port system and its interfaces to numerous actors inside and outside the port area.<br><br>The extraordinary role of maritime transport in international trade requires very efficient ports. These must meet numerous requirements in terms of economy, speed, safety and the environment. Against this background, the lecture Port Logistics deals with the planning, control, execution and monitoring of material flows and the associated information flows in the port system and its interfaces to numerous actors inside and outside the port area. The aim of the lecture Port Logistics is to convey an understanding of structures and processes in ports. The focus will be on different types of terminals, their characteristical layouts and the technical equipment used as well as the ongoing digitization and interaction of the players involved.<br><br>In addition, renowned guest speakers from science and practice will be regularly invited to discuss some lecture-relevant topics from alternative perspectives.<br><br>The following contents will be conveyed in the lectures:<br><br>• Instruction of structures and processes in the port<br>• Planning, control, implementation and monitoring of material and information flows in the port<br>• Fundamentals of different terminals, characteristical layouts and the technical equipment used<br>• Handling of current issues in port logistics |
| **Literature** | • Alderton, Patrick (2013). Port Management and Operations.<br>• Biebig, Peter and Althof, Wolfgang and Wagener, Norbert (2017). Seeverkehrswirtschaft: Kompendium.<br>• Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. Berlin Heidelberg: Springer-Verlag, 2005.<br>• Büter, Clemens (2013). Außenhandel: Grundlagen internationaler Handelsbeziehungen.<br>• Gleissner, Harald and Femerling, J. Christian (2012). Logistik: Grundlagen, Übungen, Fallbeispiele.<br>• Jahn, Carlos; Saxe, Sebastian (Hg.). Digitalization of Seaports - Visions of the Future, Stuttgart: Fraunhofer Verlag, 2017.<br>• Kummer, Sebastian (2019). Einführung in die Verkehrswirtschaft<br>• Lun, Y.H.V. and Lai, K.-H. and Cheng, T.C.E. (2010). Shipping and Logistics Management.<br>• Woitschützke, Claus-Peter (2013). Verkehrsgeografie. |

| Course L1473: Port Logistics | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Carlos Jahn |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The content of the exercise is the independent preparation of a scientific paper plus an accompanying presentation on a current topic of port logistics. The paper deals with current topics of port logistics. For example, the future challenges in sustainability and productivity of ports, the digital transformation of terminals and ports or the introduction of new regulations by the International Maritime Organization regarding the verified gross weight of containers. Due to the international orientation of the event, the paper is to be prepared in English. |
| **Literature** | • Alderton, Patrick (2013). Port Management and Operations.<br>• Biebig, Peter and Althof, Wolfgang and Wagener, Norbert (2017). Seeverkehrswirtschaft: Kompendium.<br>• Brinkmann, Birgitt. Seehäfen: Planung und Entwurf. (2005) Berlin Heidelberg: Springer-Verlag.<br>• Büter, Clemens (2013). Außenhandel: Grundlagen internationaler Handelsbeziehungen.<br>• Gleissner, Harald and Femerling, J. Christian (2012). Logistik: Grundlagen, Übungen, Fallbeispiele.<br>• Jahn, Carlos; Saxe, Sebastian (Hg.) (2017) Digitalization of Seaports - Visions of the Future, Stuttgart: Fraunhofer Verlag.<br>• Kummer, Sebastian (2019). Einführung in die Verkehrswirtschaft<br>• Lun, Y.H.V. and Lai, K.-H. and Cheng, T.C.E. (2010). Shipping and Logistics Management.<br>• Woitschützke, Claus-Peter (2013). Verkehrsgeografie. |

## Module M1012: Laboratory of Logistics Engineering and Automatisation

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Laboratory Technical Logistics and Automatisation (L1462) | Seminar | 4 | 6 |

| | |
|---|---|
| **Module Responsible** | Prof. Jochen Kreutzfeldt |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Bachelor degree in logistics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students will acquire the following knowledge:<br>1. The students will learn various technical solutions for solving logistical problems using automatisation in daily practice.<br>2. The students know the necessary steps to implement a selected technical solution to automate logistical processes.<br>3. The students know the approaches and obstacles to implement technical solutions for automating logistical processes. |
| *Skills* | The students will acquire the following skills:<br>1. The students are able to select technical solutions of automatisation for logistical problems of warehousing, conveying, sorting, order picking and identifying and evaluate the implementability of the alternatives.<br>2. The students are able to implement selected solutions of automatisation in the model scale.<br>3. The students are able to estimate the implementation costs of selected solutions of automatisation. |
| **Personal Competence** | |
| *Social Competence* | The students will acquire the following social skills:<br>1. The students are able to develop technical solutions for logistical problems and implement them on a model scale within a group of students.<br>2. The technical solutions from the group can be jointly documented and presented to an audience.<br>3. The students are able to derive new ideas and improvements from the feedback received related to their developed solution proposals. |
| *Autonomy* | The students will acquire the following competencies:<br>1. Students are able, under the guidance of supervisors, to develop and implement independently solutions of automatisation for logistical problems of warehousing, conveying, sorting, order picking and identifying.<br>2. The students are able to evaluate their technical solutions and discuss the pros and cons. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Prototype construction in laboratory with documentation (group work) |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation II. Logistics: Elective Compulsory<br>International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory |

| Course L1462: Laboratory Technical Logistics and Automatisation | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 4 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Lecturer** | Prof. Jochen Kreutzfeldt |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The aim of the seminar is the practical introduction of students in various technical solutions to logistical problems. Above all, the guided development of own solutions is the core task in the laboratory. The problems and solutions will be drawn from the following logistic topics:<br><br>(1) warehousing<br><br>(2) conveying<br><br>(3) sorting<br><br>(4) order picking<br><br>(5) identifying<br><br>The students develop technical solutions in small groups for selected problems and implement them on a lab scale. The solutions are presented to an audience and advantages and disadvantages are discussed. The recorded feedback is then added to the model solution. |
| **Literature** | Dembowski, Klaus (2015): Raspberry Pi - Das technische Handbuch. Konfiguration, Hardware, Applikationserstellung. 2., erw. und überarb. Aufl. 2015. Wiesbaden: Springer Vieweg.<br><br>Follmann, Rüdiger (2014): Das Raspberry Pi Kompendium. 2014. Aufl. Berlin, Heidelberg: Springer Berlin Heidelberg (Xpert.press).<br><br>Griemert, Rudolf (2015): Fördertechnik. Auswahl und Berechnung von Elementen und Baugruppen. [S.l.]: Morgan Kaufmann.<br><br>Hompel, Michael ten; Büchter, Hubert; Franzke, Ulrich (2008): Identifikationssysteme und Automatisierung. [Intralogistik]. Berlin, Heidelberg: Springer.<br><br>Hompel, Michael ten; Beck, Maria; Sadowsky, Volker (2011): Kommissionierung. Materialflusssysteme 2 - Planung und Berechnung der Kommissionierung in der Logistik. Berlin [u.a.]: Springer.<br><br>Jodin, Dirk; Hompel, Michael ten (2012): Sortier- und Verteilsysteme. Grundlagen, Aufbau, Berechnung und Realisierung. 2. Aufl. Berlin: Springer Berlin.<br><br>Martin, Heinrich (2014): Transport- und Lagerlogistik. Planung, Struktur, Steuerung und Kosten von Systemen der Intralogistik. 9., vollst. überarb. u. akt. Aufl. 2014. Wiesbaden: Imprint: Springer Vieweg.<br><br>Purdum, Jack J. (2014): Beginning C for Arduino. Learn C programming for the Arduino. Second edition.: Springer Berlin.<br><br>McRoberts, Michael (2014): Beginning Arduino. Second edition.: Springer Berlin. |

## Module M1100: Railways

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Railways (L1466) | Lecture | 2 | 3 |
| Railways (L1468) | Recitation Section (large) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Carsten Gertz |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Introduction to railways |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can...<br>• concieve the  entrepreneurial perspective of transport and infrastructure companies<br>• estimate intra- and intermodal competition<br>• understand regulatory and transport policy determinants<br>• reflect megatrends in the transport market<br>• understand the key performance indicators for railway transport market |
| *Skills* | Students can...<br>• apply traffic Intermodal perspective<br>• understand strategic challenges, opportunities and issues of companies<br>• recognize the relevance of sustainability and digitization for companies |
| **Personal Competence** | |
| *Social Competence* | Students can...<br>• discuss and organize task packages in small groups<br>• document and present work results in small groups |
| *Autonomy* | Students can...<br>• research and select literature<br>• submit their own shares of an extensive written work in small groups and present it collaborativly within a fixed time frame |
| **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** | |
| **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 |

| Course L1466: Railways | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Rüdiger Grube |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | |

| Course L1468: Railways | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Rüdiger Grube |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1402: Machine Learning in Logistics

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Digitalization in Traffic and Logistics (L2004) | Lecture | 1 | 2 |
| Basics of Machine Learning (L2003) | Lecture | 1 | 2 |
| Machine Learning in Logistics (L2005) | Recitation Section (small) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Carlos Jahn |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | None |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students understand specific methods of machine learning. They are able to select appropriate procedures for given data. They can explain the principals of different learning methods. In addition, they can explain the major conceptual differences of learning methods. |
| *Skills* | Students can inspect, describe, and apply selected machine learning techniques to provided data sets. Additionally they can prepare raw data for machine learning techniques.<br><br>They are able to evaluate the usability in concrete company-relevant contexts and they know how to derive the requirements and potentials of an effective application; for example in relation to controlling or forecasting approaches for the operational planning of companies. |
| **Personal Competence** | |
| *Social Competence* | Students are capable of:<br>• Discussing and organizing extensive research tasks in small groups<br>• Jointly describing, differentiating between and evaluating problems |
| *Autonomy* | Students are able:<br>• To research and select specialized literature |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** No · **Bonus** 15 % · **Form** Presentation · **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **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 |

| Course L2004: Digitalization in Traffic and Logistics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Carlos Jahn |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | When dealing with large amounts of data (big data), it is no longer possible for humans to spot all relevant data by simply looking at the raw data. In the context of logistics, the handling of temporal data and movement data plays a particularly important role. In this course the visualization, the calculation of statistics and the application of machine learning algorithms are covered. Students are given various tools for later practical application.<br><br>The course utilizes the methods learned in "Basics of Machine Learning" in the context of practical application in the field of logistics. In addition, various pre-processing steps for raw data are presented and it is discussed, under which conditions these measurements are applicable.<br><br>The lecture contents are:<br>• The Project Structure for Machine Learning<br>• Use cases for machine learning in logistics<br>• Time-related data<br>• Movement data<br>• Anomaly detection<br>• Feature engineering in image recognition |
| **Literature** | John D. Kelleher, Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies (MIT Press)<br>Aurélien Géron, Praxiseinstieg Machine Learning mit Scikit-Learn und TensorFlow : Konzepte, Tools und Techniken für intelligente Systeme (O'Reilly)<br><br>Jake VanderPlas, Data Science mit Python : das Handbuch für den Einsatz von IPython, Jupyter, NumPy, Pandas, Matplotlib, Scikit-Learn (MITP Verlags-GmbH & Co. KG) |

| Course L2003: Basics of Machine Learning | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Dozenten des SD E |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Students are able to understand specific procedures of machine learning and to use on real life examples. Students are able to use appropriate procedures for given data.<br><br>Students are able to explain the differences between instance and model based learning approaches and are able to use specific approaches in machine learning on the base of static and incremental growing data.<br><br>By the use of uncertainty the students can explain how axioms, parameter or structures can be learned. Additional the students learn to develop different cluster techniques.<br><br>Planned content:<br>• Supervised Learning:<br>    ◦ Regressions<br>    ◦ Decision trees<br>    ◦ Bayesian networks<br>    ◦ K-next neighbors<br>    ◦ Logistical regressions<br>    ◦ Neuronal Networks<br>    ◦ Support Vector Machines<br>    ◦ Ensemble Learning<br>• Unsupervised Learning:<br>    ◦ Hierarchical Clustering, K-Mean |
| **Literature** | John D. Kelleher, Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies (MIT Press)<br>Tom M. Mitchell, Machine Learning<br><br>Kevin P. Murphy, Machine Learning: A Probabilistic Perspective |

| Course L2005: Machine Learning in Logistics | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Carlos Jahn |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | In the exercise the skills which the students acquired in the lectures will be applied to real life examples. |
| **Literature** | John D. Kelleher, Fundamentals of Machine Learning for Predictive Data Analytics: Algorithms, Worked Examples, and Case Studies (MIT Press)<br>Tom M. Mitchell, Machine Learning<br><br>Kevin P. Murphy, Machine Learning: A Probabilistic Perspective<br><br>Aurélien Géron, Praxiseinstieg Machine Learning mit Scikit-Learn und TensorFlow : Konzepte, Tools und Techniken für intelligente Systeme (O'Reilly)<br><br>Jake VanderPlas, Data Science mit Python : das Handbuch für den Einsatz von IPython, Jupyter, NumPy, Pandas, Matplotlib, Scikit-Learn (MITP Verlags-GmbH & Co. KG) |

## Module M0739: Factory Planning & Production Logistics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Factory Planning (L1445) | Lecture | 3 | 3 |
| Production Logistics (L1446) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Jochen Kreutzfeldt |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Bachelor degree in logistics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students will acquire the following knowledge:<br>1. The students know the latest trends and developments in the planning of factories.<br>2. The students can explain basic procedures of factory planning and are able to deploy these procedures while considering different conditions.<br>3. The students know different methods of factory planning and are able to deal critically with these methods. |
| *Skills* | The students will acquire the following skills:<br>1. The students are able to analyze factories and other material flow systems with regard to new development and the need for change of these logistical systems.<br>2. The students are able to plan and redesign factories and other material handling systems.<br>3. The students are able to develop procedures for the implementation of new and revised material flow systems. |
| **Personal Competence** | |
| *Social Competence* | The students will acquire the following social skills:<br>1. The students are able to develop plans for the development of new and improvement of existing material flow systems within a group.<br>2. The developed planning proposal from the group work can be documented and presented together.<br>3. The students are able to derive suggestions for improvement from the feedback on the planning proposals and can even provide constructive criticism themselves. |
| *Autonomy* | The students will acquire the following independent competencies:<br>1. The students can plan and re-design material flow systems using existing planning procedures.<br>2. The students can evaluate independently the strengths and weaknesses of several techniques for factory planning and choose appropriate methods in a given context.<br>3. The students are able to carry out autonomously new plans and transformations of material flow systems. |
| **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** | International Management and Engineering: Specialisation II. Logistics: Elective Compulsory<br>International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory |

| Course L1445: Factory Planning | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Jochen Kreutzfeldt |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The lecture gives an introduction into the planning of factories and material flows. The students will learn process models and methods to plan new factories and improve existing material flow systems. The course includes three basic topics:<br>(1) Analysis of factory and material flow systems<br><br>(2) Development and re-planning of factory and material flow systems<br><br>(3) Implementation and realization of factory planning<br><br>The students are introduced into several different methods and models per topic. Practical examples and planning exercises deepen the methods and explain the application of factory planning.<br><br>The special requirements of factory planning in an international context are discussed. Specific requirements of Current trends and issues in the factory planning round off the lecture. |
| **Literature** | Bracht, Uwe; Wenzel, Sigrid; Geckler, Dieter (2018): Digitale Fabrik: Methoden und Praxisbeispiele. 2. Aufl.: Springer, Berlin.<br><br>Helbing, Kurt W. (2010): Handbuch Fabrikprojektierung. Berlin, Heidelberg: Springer Berlin Heidelberg.<br><br>Lotter, Bruno; Wiendahl, Hans-Peter (2012): Montage in der industriellen Produktion: Optimierte Abläufe, rationelle Automatisierung. 2. Aufl.: Springer, Berlin.<br><br>Müller, Egon; Engelmann, Jörg; Löffler, Thomas; Jörg, Strauch (2009): Energieeffiziente Fabriken planen und betreiben. Berlin, Heidelberg: Springer Berlin Heidelberg.<br><br>Schenk, Michael; Müller, Egon; Wirth, Siegfried (2014): Fabrikplanung und Fabrikbetrieb. Methoden für die wandlungsfähige, vernetzte und ressourceneffiziente Fabrik. 2. Aufl. Berlin [u.a.]: Springer Vieweg.<br><br>Wiendahl, Hans-Peter; Reichardt, Jürgen; Nyhuis, Peter (2014): Handbuch Fabrikplanung: Konzept, Gestaltung und Umsetzung wandlungsfähiger Produktionsstätten. 2. Aufl. Carl Hanser Verlag. |

| Course L1446: Production Logistics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dipl.-Ing. Arnd Schirrmann |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction: situation, significance and main innovation focuses of logistics in a production company, aspects of procurement, production, distribution and disposal logistics, production and transport networks<br>• Logistics as a production strategy: logistics-oriented method of working in a factory, throughput time, corporate strategy, structured networking, reducing complexity, integrated organization, integrated product and production logistics (IPPL)<br>• Logistics-compatible production and process structuring; logistics-compatible product, material flow, information and organizational structures<br>• Logistics-oriented production control: situation and development tendencies, logistics and cybernetics, market-oriented production planning, control, monitoring, PPS systems and production control, cybernetic production organization and control, production logistics control systems.<br>• Production logistics planning: key performance indicators, developing a production logistics concept, computerized aids to planning production logistics, IPPL functions, economic efficiency of logistics projects<br>• Production logistics controlling: production logistics and controlling, material flow-oriented cost transparency, cost controlling (process cost accounting, costs model in IPPL), process controlling (integrated production system, methods and tools, MEPOT.net method portal) |
| **Literature** | Pawellek, G.: Produktionslogistik: Planung - Steuerung - Controlling. Carl Hanser Verlag 2007 |

## Module M1406: Transport Aircraft Operations

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Airline Operations (L1310) | Lecture | 3 | 3 |
| Airport Operations (L1276) | Lecture | 3 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Volker Gollnick |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Lecture Air Transportation Systems<br><br>Basic Knowledge in Aviation, logistics, mobility |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Principles of Air Traffic Management and technologies<br><br>Design and modelling of traffic flows, avionics and sensor systems, cockpit design<br><br>Principles of Airline organization and business<br><br>Fleet setup, fleet operation, aircraft selection, maintenance, repair overhaul technologies and business |
| *Skills* | • Understanding and application of different interdisciplinary interdependencies<br>• Integration and assessment of new technologies in the air transportation system<br>• Modelling and assessment of flight guidance systems<br>• Airline fleet planning and fleet operation |
| **Personal Competence** | |
| *Social Competence* | • Working in interdisciplinary teams<br>• Communication |
| *Autonomy* | Organization of workflows and -strategies |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation II. Logistics: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory |

### Course L1310: Airline Operations

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Volker Gollnick, Dr. Karl Echtermeyer |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introdution and overview<br>2. Airline business models<br>3. Interdependencies in flight planning (network management, slot management, netzwork structures, aircraft circulation)<br>4. Operative flight preparation (weight & balance, payload/range, etc.)<br>5. fleet policy<br>6. Aircraft assessment and fleet planning<br>7. Airline organisation<br>8. Aircraft maintenance, repair and overhaul |
| **Literature** | Volker Gollnick, Dieter Schmitt: The Air Transport System, Springer Berlin Heidelberg New York, 2014<br><br>Paul Clark: Buying the big jets, Ashgate 2008<br><br>Mike Hirst: The Air Transport System, AIAA, 2008 |

| Course L1276: Airport Operations | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Volker Gollnick, Dr. Peter Willems |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | FA-F Flight Operations Flight Operations - Production Infrastructures Operations Planning Master plan Airport capacity Ground handling Terminal operations |
| **Literature** | Richard de Neufville, Amedeo Odoni: Airport Systems, McGraw Hill, 2003 |

## Specialization II. Aviation Systems

### Module M0764: Aircraft Systems II

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Aircraft Systems II (L0736) | Lecture | 3 | 4 |
| Aircraft Systems II (L0740) | Recitation Section (large) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Frank Thielecke |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | basic knowledge of:<br>• mathematics<br>• mechanics<br>• thermo dynamics<br>• electronics<br>• fluid technology<br>• control technology |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to…<br>• describe the structure of primary flight control systems as well as actuation-, avionic-, fuel- and landing gear-systems in general along with corresponding properties and applications.<br>• explain different configurations and designs and their origins<br>• explain atmospheric conditions for icing such as the functionality of anti-ice systems |
| *Skills* | Students are able to…<br>• size primary flight control actuation systems<br>• perform a controller design process for the flight control actuators<br>• design high-lift kinematics<br>• design and analyse landing gear systems<br>• design anti-ice systems |
| **Personal Competence** | |
| *Social Competence* | Students are able to:<br>• Develop joint solutions in mixed teams |
| *Autonomy* | Students are able to:<br>• derive requirements and perform appropriate yet simplified design processes for aircraft systems from complex issues and circumstances in a self-reliant manner |
| **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** | 165 Minutes |
| **Assignment for the Following Curricula** | Aircraft Systems Engineering: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation II. Aviation Systems: 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: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory |

| Course L0736: Aircraft Systems II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Frank Thielecke |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Actuation (Principles of actuators; electro-mechanical actuators; modeling, analysis and sizing of position control systems; hydro-mechanic actuation systems)<br>• Flight Control Systems (control surfaces, hinge moments; requirements of stability and controllability, actuation power; principles of reversible and irreversible flight control systems; servo actuation systems)<br>• Landing Gear Systems (Configurations and geometries; analysis of landing gear systems with respect to damper dynamics, dynamics of the breaking aircraft and power consumption; design and analysis of breaking systems with respect to energy and heat; anti-skit systems)<br>• Fuel Systems (Architectures; aviation fuels; system components; fueling system; tank inerting system; fuel management; trim tank)<br>• De- and Anti-Ice Systems: (Atmospheric icing conditions; principles of de- and anti-ice systems) |
| **Literature** | • Moir, Seabridge: Aircraft Systems<br>• Torenbek: Synthesis of Subsonic Airplane Design<br>• Curry: Aircraft Landing Gear Design: Principles and Practices |

| Course L0740: Aircraft Systems II | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Frank Thielecke |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1156: Systems Engineering

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Systems Engineering (L1547) | Lecture | 3 | 4 |
| Systems Engineering (L1548) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Ralf God |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge in:<br>• Mathematics<br>• Mechanics<br>• Thermodynamics<br>• Electrical Engineering<br>• Control Systems<br><br>Previous knowledge in:<br>• Aircraft Cabin Systems |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to:<br>• understand systems engineering process models, methods and tools for the development of complex Systems<br>• describe innovation processes and the need for technology Management<br>• explain the aircraft development process and the process of type certification for aircraft<br>• explain the system development process, including requirements for systems reliability<br>• identify environmental conditions and test procedures for airborne Equipment<br>• value the methodology of requirements-based engineering (RBE) and model-based requirements engineering (MBRE) |
| *Skills* | Students are able to:<br>• plan the process for the development of complex Systems<br>• organize the development phases and development Tasks<br>• assign required business activities and technical Tasks<br>• apply systems engineering methods and tools |
| **Personal Competence** | |
| *Social Competence* | Students are able to:<br>• understand their responsibilities within a development team and integrate themselves with their role in the overall process |
| *Autonomy* | Students are able to:<br>• interact and communicate in a development team which has distributed tasks |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 Minutes |
| **Assignment for the Following Curricula** | Aircraft Systems Engineering: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory<br>Mechatronics: Specialisation System Design: Elective Compulsory<br>Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Product Development: 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: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory |

| Course L1547: Systems Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Ralf God |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The objective of the lecture with the corresponding exercise is to accomplish the prerequisites for the development and integration of complex systems using the example of commercial aircraft and cabin systems. Competences in the systems engineering process, tools and methods is to be achieved. Regulations, guidelines and certification issues will be known.<br><br>Key aspects of the course are processes for innovation and technology management, system design, system integration and certification as well as tools and methods for systems engineering:<br>• Innovation processes<br>• IP-protection<br>• Technology management<br>• Systems engineering<br>• Aircraft program<br>• Certification issues<br>• Systems development<br>• Safety objectives and fault tolerance<br>• Environmental and operating conditions<br>• Tools for systems engineering<br>• Requirements-based engineering (RBE)<br>• Model-based requirements engineering (MBRE) |
| **Literature** | - Skript zur Vorlesung<br>- diverse Normen und Richtlinien (EASA, FAA, RTCA, SAE)<br>- Hauschildt, J., Salomo, S.: Innovationsmanagement. Vahlen, 5. Auflage, 2010<br>- NASA Systems Engineering Handbook, National Aeronautics and Space Administration, 2007<br>- Hinsch, M.: Industrielles Luftfahrtmanagement: Technik und Organisation luftfahrttechnischer Betriebe. Springer, 2010<br>- De Florio, P.: Airworthiness: An Introduction to Aircraft Certification. Elsevier Ltd., 2010<br>- Pohl, K.: Requirements Engineering. Grundlagen, Prinzipien, Techniken. 2. korrigierte Auflage, dpunkt.Verlag, 2008 |

| Course L1548: Systems Engineering | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Ralf God |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0721: Air Conditioning

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Air Conditioning (L0594) | Lecture | 3 | 5 |
| Air Conditioning (L0595) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Gerhard Schmitz |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Technical Thermodynamics I, II, Fluid Dynamics, Heat Transfer |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students know the different kinds of air conditioning systems for buildings and mobile applications and how these systems are controlled. They are familiar with the change of state of humid air and are able to draw the state changes in a h1+x,x-diagram. They are able to calculate the minimum airflow needed for hygienic conditions in rooms and can choose suitable filters. They know the basic flow pattern in rooms and are able to calculate the air velocity in rooms with the help of simple methods. They know the principles to calculate an air duct network. They know the different possibilities to produce cold and are able to draw these processes into suitable thermodynamic diagrams. They know the criteria for the assessment of refrigerants. |
| *Skills* | Students are able to configure air condition systems for buildings and mobile applications. They are able to calculate an air duct network and have the ability to perform simple planning tasks, regarding natural heat sources and heat sinks. They can transfer research knowledge into practice. They are able to perform scientific work in the field of air conditioning. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss in small groups and develop an approach. |
| *Autonomy* | Students are able to define independently tasks, to get new knowledge from existing knowledge as well as to find ways to use the knowledge in practice. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min |
| **Assignment for the Following Curricula** | Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory<br>Energy Systems: Specialisation Energy Systems: Elective Compulsory<br>Energy Systems: Specialisation Marine Engineering: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory |

| Course L0594: Air Conditioning | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 5 |
| **Workload in Hours** | Independent Study Time 108, Study Time in Lecture 42 |
| **Lecturer** | Prof. Gerhard Schmitz |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Overview<br><br>1.1 Kinds of air conditioning systems<br><br>1.2 Ventilating<br><br>1.3 Function of an air condition system<br><br>2. Thermodynamic processes<br><br>2.1 Psychrometric chart<br><br>2.2 Mixer preheater, heater<br><br>2.3 Cooler<br><br>2.4 Humidifier<br><br>2.5 Air conditioning process in a Psychrometric chart<br><br>2.6 Desiccant assisted air conditioning<br><br>3. Calculation of heating and cooling loads<br><br>3.1 Heating loads<br><br>3.2 Cooling loads<br><br>3.3 Calculation of inner cooling load<br><br>3.4 Calculation of outer cooling load<br><br>4. Ventilating systems<br><br>4.1 Fresh air demand<br><br>4.2 Air flow in rooms<br><br>4.3 Calculation of duct systems<br><br>4.4 Fans<br><br>4.5 Filters<br><br>5. Refrigeration systems<br><br>5.1. compression chillers<br><br>5.2Absorption chillers |
| **Literature** | • Schmitz, G.: Klimaanlagen, Skript zur Vorlesung<br>• VDI Wärmeatlas, 11. Auflage, Springer Verlag, Düsseldorf 2013<br>• Herwig, H.; Moschallski, A.: Wärmeübertragung, Vieweg+Teubner Verlag, Wiesbaden 2009<br>• Recknagel, H.; Sprenger, E.; Schrammek, E.-R.: Taschenbuch für Heizung- und Klimatechnik 2013/2014, 76. Auflage, Deutscher Industrieverlag, 2013 |

| Course L0595: Air Conditioning | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Gerhard Schmitz |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

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

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

| | |
|---|---|
| **Module Responsible** | Prof. Otto von Estorff |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Mechanics I (Statics, Mechanics of Materials) and Mechanics II (Hydrostatics, Kinematics, Dynamics)<br><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 in acoustics regarding acoustic waves, noise protection, and psycho acoustics and are able to give an overview of the corresponding theoretical and methodical basis. |
| *Skills* | The students are capable to handle engineering problems in acoustics by theory-based application of the demanding methodologies and measurement procedures treated within the module. |
| **Personal Competence** | |
| *Social Competence* | Students can work in small groups on specific problems to arrive at joint solutions. |
| *Autonomy* | The students are able to independently solve challenging acoustical problems in the areas treated within the module. Possible conflicting issues and limitations can be identified and the results are critically scrutinized. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | Energy Systems: Core Qualification: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Aviation Systems: 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>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory |

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

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

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

## Module M0763: Aircraft Energy Systems (FS1)

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Aircraft Systems I (L0735) | Lecture | 3 | 4 |
| Aircraft Systems I (L0739) | Recitation Section (large) | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Frank Thielecke |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge in:<br>• Mathematics<br>• Mechanics<br>• Thermodynamics<br>• Electrical Engineering<br>• Hydraulics<br>• Control Systems |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to:<br>• Describe essential components and design points of hydraulic, electrical and high-lift systems<br>• Give an overview of the functionality of air conditioning systems<br>• Explain the need for high-lift systems such as ist functionality and effects<br>• Assess the challenge during the design of supply systems of an aircraft |
| *Skills* | Students are able to:<br>• Design hydraulic and electric supply systems of aircrafts<br>• Design high-lift systems of aircrafts<br>• Analyze the thermodynamic behaviour of air conditioning systems |
| **Personal Competence** | |
| *Social Competence* | Students are able to:<br>• Perform system design in groups and present and discuss results |
| *Autonomy* | Students are able to:<br>• Reflect the contents of lectures autonomously |
| **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** | 165 Minutes |
| **Assignment for the Following Curricula** | Energy Systems: Specialisation Energy Systems: Elective Compulsory<br>Aircraft Systems Engineering: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation II. Aviation Systems: 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: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory |

| Course L0735: Aircraft Systems I | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Frank Thielecke |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Hydraulic Energy Systems (Fluids; pressure loss in valves and pipes; components of hydraulic systems like pumps, valves, etc.; pressure/flow characteristics; actuators; tanks; power and heat balances; emergency power)<br>• Electric Energy Systems (Generators; constant-speed-drives; DC and AC converters; electrical power distribution; bus systems; monitoring; load analysis)<br>• High Lift Systems (Principles; investigation of loads and system actuation power; principles and sizing of actuation and positioning systems; safety requirements and devices)<br>• Environmental Control Systems (Thermodynamic analysis; expansion and compression cooling systems; control strategies; cabin pressure control systems) |
| **Literature** | • Moir, Seabridge: Aircraft Systems<br>• Green: Aircraft Hydraulic Systems<br>• Torenbek: Synthesis of Subsonic Airplane Design<br>• SAE1991: ARP; Air Conditioning Systems for Subsonic Airplanes |

| Course L0739: Aircraft Systems I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Frank Thielecke |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0771: Flight Physics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Aerodynamics and Flight Mechanics I (L0727) | Lecture | 3 | 3 |
| Flight Mechanics II (L0730) | Lecture | 2 | 2 |
| Flight Mechanics II (L0731) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Frank Thielecke |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge in:<br>• Mathematics<br>• Mechanics<br>• Thermodynamics<br>• Aviation |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | |
| *Skills* | |
| **Personal Competence** | |
| *Social Competence* | |
| *Autonomy* | |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 Minutes (WS) + 90 Minutes (SS) |
| **Assignment for the Following Curricula** | Aircraft Systems Engineering: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation II. Aviation Systems: 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 Aircraft Systems Engineering: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory |

### Course L0727: Aerodynamics and Flight Mechanics I

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Frank Thielecke, Dr. Ralf Heinrich, Mike Montel |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Aerodynamics (fundamental equations of aerodynamics; compressible and incompressible flows; airfoils and wings; viscous flows)<br>• Flight Mechanics (Equations of motion; flight performance; control surfaces; derivatives; lateral stability and control; trim conditions; flight maneuvers) |
| **Literature** | • Schlichting, H.; Truckenbrodt, E.: Aerodynamik des Flugzeuges I und II<br>• Etkin, B.: Dynamics of Atmospheric Flight<br>• Sachs/Hafer: Flugmechanik<br>• Brockhaus: Flugregelung<br>• J.D. Anderson: Introduction to flight |

| Course L0730: Flight Mechanics II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Frank Thielecke, Mike Montel |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • stationary asymmetric flight<br>• dynamics of lateral movement<br>• methods of flight simulation<br>• eyperimental methods of flight mechanics<br>• model validation using system identification<br>• wind tunnel techniques |
| **Literature** | • Schlichting, H.; Truckenbrodt, E.: Aerodynamik des Flugzeuges I und II<br>• Etkin, B.: Dynamics of Atmospheric Flight<br>• Sachs/Hafer: Flugmechanik<br>• Brockhaus: Flugregelung<br>• J.D. Anderson: Introduction to flight |

| Course L0731: Flight Mechanics II | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Frank Thielecke, Mike Montel |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0812: Aircraft Design

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Aircraft Design I (Design of Transport Aircraft) (L0820) | Lecture | 2 | 2 |
| Aircraft Design II (Conceptual Design of Rotorcraft, special operations aircraft, UAV) (L0844) | Lecture | 2 | 2 |
| Aircraft Design II (Conceptual Design of Rotorcraft, special operations aircraft, UAV) (L0847) | Recitation Section (large) | 1 | 1 |
| Aircraft Design I (L0834) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Volker Gollnick |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Bachelor Mech. Eng.<br>• Vordiplom Mech. Eng.<br>• Module Air Transport Systems |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | 1. Principle understanding of integrated aircraft design<br>2. Understanding of the interactions and contributions of the various disciplines<br>3. Impact of the relevant design parameter on the aircraft design<br>4. Introduction of the principle design methods |
| *Skills* | Understanding and application of design and calculation methods<br><br>Understanding of interdisciplinary and integrative interdependencies |
| **Personal Competence** | |
| *Social Competence* | Working in interdisciplinary teams<br><br>Communication |
| *Autonomy* | Organization of workflows and -strategies |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Aircraft Systems Engineering: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory |

| Course L0820: Aircraft Design I (Design of Transport Aircraft) | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Volker Gollnick |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Introduction into the aircraft design process<br><br>1. Introduction/process of aircraft design/various aircraft configurations<br>2. Requirements and design objectives, main design parameter (u.a. payload-range-diagramme)<br>3. Statistical methods in overall aircraft design/data base methods<br>4. Principles of aircraft performance design (stability, V-n-diagramme)<br>5. Principles of aerodynamic aircraft design (polar, geometry, 2D/3D aerodynamics)<br>6. Principles of structural fuselage and wing design (mass analysis, beam/tube models, geometry)<br>7. Principles of engine design and integration<br>8. Cruise design<br>9. Design of runway and landing field length<br>10. Cabin design (fuselage dimensioning, cabin interior, loading systems)<br>11. System- and equipment aspects<br>12. Design variations and operating cost calculation |
| **Literature** | J. Roskam: "Airplane Design"<br><br>D.P. Raymer: "Aircraft Design - A Conceptual Approach"<br><br>J.P. Fielding: "Intorduction to Aircraft Design"<br><br>Jenkinson, Simpkon, Rhods: "Civil Jet Aircraft Design" |

| Course L0844: Aircraft Design II (Conceptual Design of Rotorcraft, special operations aircraft, UAV) | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Volker Gollnick, Dr. Bernd Liebhardt |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | Take Off and landing<br><br>Loads on Aircraft<br><br>Operation Cost<br><br>Principles of Rotorcraft Design<br><br>Principles of high performance aircraft design<br><br>Principles of special operations aircraft design<br><br>Principles of Unmanned Air Systems design |
| **Literature** | Gareth Padfield: Helicopter Flight Dynamics<br><br>Raymond Prouty: Helicopter Performance Stability and Control<br><br>Klaus Hünecke: Das Kampfflugzeug von Heute |

| Course L0847: Aircraft Design II (Conceptual Design of Rotorcraft, special operations aircraft, UAV) | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Volker Gollnick, Dr. Bernd Liebhardt |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0834: Aircraft Design I | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Volker Gollnick |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Training in applying MatLab<br><br>Application of design methods for civil aircraft concerning:<br><br>Fuselage and Cabin sizing and design<br><br>Calculation of aircraft masses<br><br>Aerodynamic and geometric wing design<br><br>TakeOff, landing cruise performance calculation<br><br>Manoevre and gust load calculation |
| **Literature** | J. Roskam: "Airplane Design"<br><br>D.P. Raymer: "Aircraft Design - A Conceptual Approach"<br><br>J.P. Fielding: "Intorduction to Aircraft Design"<br><br>Jenkinson, Simpkon, Rhods: "Civil Jet Aircraft Design" |

## Module M1032: Airport Planning and Operations

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Airport Operations (L1276) | Lecture | 3 | 3 |
| Airport Planning (L1275) | Lecture | 2 | 2 |
| Airport Planning (L1469) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Volker Gollnick |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Bachelor Mech. Eng.<br>• Vordiplom Mech. Eng.<br>• Lecture Air Transportation Systems |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | 1. Regulatory principles of airport planning and operations<br>2. Design of an airport incl. Regulatory baselines<br>3. Airport operation in the terminal and at the airfield |
| *Skills* | • Understanding of different interdisciplinary interdependencies<br>• Planning and design of an airport<br>• Modelling and assessment of airport operation |
| **Personal Competence** | |
| *Social Competence* | • Working in interdisciplinary teams<br>• Communication |
| *Autonomy* | Organization of workflows and -strategies |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory |

### Course L1276: Airport Operations

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Volker Gollnick, Dr. Peter Willems |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | FA-F Flight Operations Flight Operations - Production Infrastructures Operations Planning Master plan Airport capacity Ground handling Terminal operations |
| **Literature** | Richard de Neufville, Amedeo Odoni: Airport Systems, McGraw Hill, 2003 |

| Course L1275: Airport Planning | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Volker Gollnick, Dr. Ulrich Häp |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | 1. Introduction, definitions, overviewg<br>2. Runway systems<br>3. Air space strucutres around airports<br>4. Airfield lightings, marking and information<br>5. Airfield and terminal configuration |
| **Literature** | N. Ashford, Martin Stanton, Clifton Moore: Airport Operations, John Wiley & Sons, 1991<br><br>Richard de Neufville, Amedeo Odoni: Airport Systems, Aviation Week Books, MacGraw Hill, 2003 |

| Course L1469: Airport Planning | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Volker Gollnick, Dr. Ulrich Häp |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1091: Flight Guidance and Control

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Introduction to Flight Guidance (L0848) | Lecture | 3 | 2 |
| Introduction to Flight Guidance (L0854) | Recitation Section (large) | 1 | 1 |
| Flight Control (L2374) | Lecture | 2 | 2 |
| Flight Control (L2375) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Volker Gollnick |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Bachelor Mech. Eng.<br>• Vordiplom Mech. Eng.<br>• Lecture Air Transportation Systems |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | 1. Principles of Air Traffic Management and technologies<br>2. Design and modelling of traffic flows, avionics and sensor systems, cockpit design<br>3. Principles of flight control systems development<br>4. Air vehicle description as control path (fixed wing, rotary wing, special)<br>5. Characteristics of control elements<br>6. Flight control systems design für stabilization, path control, navigation |
| *Skills* | • Understanding and application of different interdisciplinary interdependencies<br>• Integration and assessment of new technologies in the air transportation system<br>• Modelling and assessment of flight guidance systems<br>• Airline fleet planning and fleet operation |
| **Personal Competence** | |
| *Social Competence* | • Working in interdisciplinary teams<br>• Communication |
| *Autonomy* | Organization of workflows and -strategies |
| **Workload in Hours** | Independent Study Time 82, Study Time in Lecture 98 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 min |
| **Assignment for the Following Curricula** | Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Air Transportation Systems: Compulsory<br>Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Specialisation Infrastructure and Mobility: Elective Compulsory |

### Course L0848: Introduction to Flight Guidance

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 18, Study Time in Lecture 42 |
| **Lecturer** | Prof. Volker Gollnick |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Introduction and motivation Flight guidance principles (airspace structures, organization of air navigation services, etc.) Navigation Radio navigation Satellite navigation Principles of flight measurement techniques Measurement of position (geometric methods, distance measurement, direction measurement) Determination of the aircraft attitude (magnetic field- and inertial sensors) Measurement of speed Airspace surveillance (radar systems) Commuication systems Avionics architectures (computer systems, bus systems) Cockpit systems and displays (cockpit design, cockpit equipment) |
| **Literature** | Rudolf Brockhaus, Robert Luckner, Wolfgang Alles: "Flugregelung", Springer Berlin Heidelberg New York, 2012 Holger Flühr: "Avionik und Flugsicherungssysteme", Springer Berlin Heidelberg New York, 2013 Volker Gollnick, Dieter Schmitt "Air Transport Systems", Springer Berlin Heidelberg New York, 2014 |

| Course L0854: Introduction to Flight Guidance | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Volker Gollnick |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L2374: Flight Control | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Volker Gollnick |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The course will provide knowledge how to describe flight vehicle as a control system. Further it gives inside into the design, layout and optimization of controller for stabilisation and control of flight states and guidance modes.<br><br>The course is intended to enable participants in the layout of flight control systems presenting the major methods and tools |
| **Literature** | Brockhaus, Alles, Luckner: Flugregelung, Springer Verlag, 2011<br><br>R.P.G Collinson: Introduction to Avionics Systems, Springer Verlag, 2011 |

| Course L2375: Flight Control | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Volker Gollnick |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1155: Aircraft Cabin Systems

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Aircraft Cabin Systems (L1545) | Lecture | 3 | 4 |
| Aircraft Cabin Systems (L1546) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Ralf God |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge in:<br>• Mathematics<br>• Mechanics<br>• Thermodynamics<br>• Electrical Engineering<br>• Control Systems |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to:<br>• describe cabin operations, equipment in the cabin and cabin Systems<br>• explain the functional and non-functional requirements for cabin Systems<br>• elucidate the necessity of cabin operating systems and emergency Systems<br>• assess the challenges human factors integration in a cabin environment |
| *Skills* | Students are able to:<br>• design a cabin layout for a given business model of an Airline<br>• design cabin systems for safe operations<br>• design emergency systems for safe man-machine interaction<br>• solve comfort needs and entertainment requirements in the cabin |
| **Personal Competence** | |
| *Social Competence* | Students are able to:<br>• understand existing system solutions and discuss their ideas with experts |
| *Autonomy* | Students are able to:<br>• Reflect the contents of lectures and expert presentations self-dependent |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 Minutes |
| **Assignment for the Following Curricula** | Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory<br>Energy Systems: Specialisation Energy Systems: Elective Compulsory<br>Aircraft Systems Engineering: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation II. Aviation Systems: 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 Aircraft Systems Engineering: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory |

| Course L1545: Aircraft Cabin Systems | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Ralf God |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The objective of the lecture with the corresponding exercise is the acquisition of knowledge about aircraft cabin systems and cabin operations. A basic understanding of technological and systems engineering effort to maintain an artificial but comfortable and safe travel and working environment at cruising altitude is to be achieved.<br><br>The course provides a comprehensive overview of current technology and cabin systems in modern passenger aircraft. The Fulfillment of requirements for the cabin as the central system of work are covered on the basis of the topics comfort, ergonomics, human factors, operational processes, maintenance and energy supply:<br>• Materials used in the cabin<br>• Ergonomics and human factors<br>• Cabin interior and non-electrical systems<br>• Cabin electrical systems and lights<br>• Cabin electronics, communication-, information- and IFE-systems<br>• Cabin and passenger process chains<br>• RFID Aircraft Parts Marking<br>• Energy sources and energy conversion |
| **Literature** | - Skript zur Vorlesung<br>- Jenkinson, L.R., Simpkin, P., Rhodes, D.: Civil Jet Aircraft Design. London: Arnold, 1999<br>- Rossow, C.-C., Wolf, K., Horst, P. (Hrsg.): Handbuch der Luftfahrzeugtechnik. Carl Hanser Verlag, 2014<br>- Moir, I., Seabridge, A.: Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, Wiley 2008<br>- Davies, M.: The standard handbook for aeronautical and astronautical engineers. McGraw-Hill, 2003<br>- Kompendium der Flugmedizin. Verbesserte und ergänzte Neuauflage, Nachdruck April 2006. Fürstenfeldbruck, 2006<br>- Campbell, F.C.: Manufacturing Technology for Aerospace Structural Materials. Elsevier Ltd., 2006 |

| Course L1546: Aircraft Cabin Systems | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Ralf God |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1043: Aircraft Systems Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fatigue & Damage Tolerance (L0310) | Lecture | 2 | 3 |
| Lightweight Design Practical Course (L1258) | Project-/problem-based Learning | 3 | 3 |
| Aviation Security (L1549) | Lecture | 2 | 2 |
| Aviation Security (L1550) | Recitation Section (small) | 1 | 1 |
| Mechanisms, Systems and Processes of Materials Testing (L0950) | Lecture | 2 | 2 |
| Turbo Jet Engines (L0908) | Lecture | 2 | 3 |
| Structural Mechanics of Fibre Reinforced Composites (L1514) | Lecture | 2 | 3 |
| System Simulation (L1820) | Lecture | 2 | 2 |
| System Simulation (L1821) | Recitation Section (large) | 1 | 2 |
| Materials Testing (L0949) | Lecture | 2 | 2 |
| Reliability in Engineering Dynamics (L0176) | Lecture | 2 | 2 |
| Reliability in Engineering Dynamics (L1303) | Recitation Section (small) | 1 | 2 |
| Reliability of avionics assemblies (L1554) | Lecture | 2 | 2 |
| Reliability of avionics assemblies (L1555) | Recitation Section (small) | 1 | 1 |
| Reliability of Aircraft Systems (L0749) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Frank Thielecke |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge in:<br>• Mathematics<br>• Mechanics<br>• Thermodynamics<br>• Electrical Engineering<br>• Hydraulics<br>• Control Systems |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students are able to find their way through selected special areas within systems engineering, air transportation system and material science<br>• Students are able to explain basic models and procedures in selected special areas.<br>• Students are able to interrelate scientific and technical knowledge. |
| *Skills* | Students are able to apply basic methods in selected areas of engineering. |
| **Personal Competence** | |
| *Social Competence* | |
| *Autonomy* | Students can chose independently, in which fields they want to deepen their knowledge and skills through the election of courses. |
| **Workload in Hours** | Depends on choice of courses |
| **Credit points** | 6 |
| **Assignment for the Following Curricula** | Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Cabin Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: 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 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 L1549: Aviation Security | |
|---|---|
| **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** | Prof. Ralf God |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The objective of the lecture with the corresponding exercise is the acquisition of knowledge about tasks and measures for protection against attacks on the security of the commercial air transport system. Tasks and measures will be elicited in the context of the three system components man, technology and organization.<br><br>The course teaches the basics of aviation security. Aviation security is a necessary prerequisite for an economically successful air transport system. Risk management for the entire system can only be successful in an integrated approach, considering man, technology and organization:<br>• Historical development<br>• The special role of air transport<br>• Motive and attack vectors<br>• The human factor<br>• Threats and risk<br>• Regulations and law<br>• Organization and implementation of aviation security tasks<br>• Passenger and baggage checks<br>• Cargo screening and secure supply chain<br>• Safety technologies |
| **Literature** | - Skript zur Vorlesung<br>- Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011<br>- Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008 |

| Course L1550: Aviation Security | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Examination Form** | Klausur |
| **Examination duration and scale** | 90 Minuten |
| **Lecturer** | Prof. Ralf God |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The objective of the lecture with the corresponding exercise is the acquisition of knowledge about tasks and measures for protection against attacks on the security of the commercial air transport system. Tasks and measures will be elicited in the context of the three system components man, technology and organization.<br><br>The course teaches the basics of aviation security. Aviation security is a necessary prerequisite for an economically successful air transport system. Risk management for the entire system can only be successful in an integrated approach, considering man, technology and organization:<br>• Historical development<br>• The special role of air transport<br>• Motive and attack vectors<br>• The human factor<br>• Threats and risk<br>• Regulations and law<br>• Organization and implementation of aviation security tasks<br>• Passenger and baggage checks<br>• Cargo screening and secure supply chain<br>• Safety technologies |
| **Literature** | - Skript zur Vorlesung<br><br>- Giemulla, E.M., Rothe B.R. (Hrsg.): Handbuch Luftsicherheit. Universitätsverlag TU Berlin, 2011<br><br>- Thomas, A.R. (Ed.): Aviation Security Management. Praeger Security International, 2008 |

| Course L0950: Mechanisms, Systems and Processes of Materials Testing | |
|---|---|
| **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** | Dr. Jan Oke Peters |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Application, analysis and discussion of basic and advanced testing methods to ensure correct selection of applicable testing procedure for investigation of part/materials deficiencies<br><br>• Stress-strain relationships<br>• Strain gauge application<br>• Visko elastic behavior<br>• Tensile test (strain hardening, necking, strain rate)<br>• Compression test, bending test, torsion test<br>• Crack growth upon static loading (J-Integral)<br>• Crack growth upon cyclic loading (micro- und macro cracks)<br>• Effect of notches<br>• Creep testing (physical creep test, influence of stress and temperature, Larson Miller parameter)<br>• Wear testing<br>• Non destructive testing application for overhaul of jet engines |
| **Literature** | • E. Macherauch: Praktikum in Werkstoffkunde, Vieweg<br>• G. E. Dieter: Mechanical Metallurgy, McGraw-Hill<br>• R. Bürgel: Lehr- und Übungsbuch Festigkeitslehre, Vieweg<br>• R. Bürgel: Werkstoffe sícher beurteilen und richtig einsetzen, Vieweg |

| Course L0908: Turbo Jet Engines | |
|---|---|
| **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. Burkhard Andrich |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Cycle of the gas turbine<br>• Thermodynamics of gas turbine components<br>• Wing-, grid- and stage-sizing<br>• Operating characteristics of gas turbine components<br>• Sizing criteria's for jet engines<br>• Development trends of gas turbines and jet engines<br>• Maintenance of jet engines |
| **Literature** | • Bräunling: Flugzeugtriebwerke<br>• Engmann: Technologie des Fliegens<br>• Kerrebrock: Aircraft Engines and Gas Turbines |

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

| Course L1820: System Simulation | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Examination Form** | Mündliche Prüfung |
| **Examination duration and scale** | 30 min |
| **Lecturer** | Dr. Stefan Wischhusen |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Lecture about equation-based, physical modelling using the modelling language Modelica and the free simulation tool OpenModelica.<br>• Instruction and modelling of physical processes<br>• Modelling and limits of model<br>• Time constant, stiffness, stability, step size<br>• Terms of object orientated programming<br>• Differential equations of simple systems<br>• Introduction into Modelica<br>• Introduction into simulation tool<br>• Example:Hydraulic systems and heat transfer<br>• Example: System with different subsystems |
| **Literature** | [1] Modelica Association: "Modelica Language Specification - Version 3.4", Linköping, Sweden, 2 0 1 7<br><br>[2] M. Tiller: "Modelica by Example", http://book.xogeny.com, 2014.<br><br>[3] M. Otter, H. Elmqvist, et al.: "Objektorientierte Modellierung Physikalischer Systeme", at- Automatisierungstechnik (german), Teil 1 - 17, Oldenbourg Verlag, 1999 - 2000.<br><br>[4] P. Fritzson: "Principles of Object-Oriented Modeling and Simulation with Modelica 3.3", Wiley-IEEE Press, New York, 2015.<br><br>[5] P. Fritzson: "Introduction to Modeling and Simulation of Technical and Physical Systems with Modelica", Wiley, New York, 2011. |

| Course L1821: System Simulation | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Examination Form** | Mündliche Prüfung |
| **Examination duration and scale** | 30 min |
| **Lecturer** | Dr. Stefan Wischhusen |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0949: Materials Testing | |
|---|---|
| **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** | Dr. Jan Oke Peters |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Application and analysis of basic mechanical as well as non-destructive testing of materials<br>• Determination elastic constants<br>• Tensile test<br>• Fatigue test (testing with constant stress, strain, or plastiv strain amplitude, low and high cycle fatigue, mean stress effect)<br>• Crack growth upon static loading (stress intensity factor, fracture toughness)<br>• Creep test<br>• Hardness test<br>• Charpy impact test<br>• Non destructive testing |
| **Literature** | E. Macherauch: Praktikum in Werkstoffkunde, Vieweg<br>G. E. Dieter: Mechanical Metallurgy, McGraw-Hill |

| Course L0176: Reliability in Engineering Dynamics | |
|---|---|
| **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 min. |
| **Lecturer** | Prof. Uwe Weltin |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | Method for calculation and testing of reliability of dynamic machine systems<br>• Modeling<br>• System identification<br>• Simulation<br>• Processing of measurement data<br>• Damage accumulation<br>• Test planning and execution |
| **Literature** | Bertsche, B.: Reliability in Automotive and Mechanical Engineering. Springer, 2008. ISBN: 978-3-540-33969-4<br>Inman, Daniel J.: Engineering Vibration. Prentice Hall, 3rd Ed., 2007. ISBN-13: 978-0132281737<br>Dresig, H., Holzweißig, F.: Maschinendynamik, Springer Verlag, 9. Auflage, 2009. ISBN 3540876936.<br>VDA (Hg.): Zuverlässigkeitssicherung bei Automobilherstellern und Lieferanten. Band 3 Teil 2, 3. überarbeitete Auflage, 2004. ISSN 0943-9412 |

| Course L1303: Reliability in Engineering Dynamics | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Examination Form** | Klausur |
| **Examination duration and scale** | 90 min |
| **Lecturer** | Prof. Uwe Weltin |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1554: Reliability of avionics assemblies | |
|---|---|
| **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** | Prof. Ralf God |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:<br>• Survey of the role of electronics in aviation<br>• System levels: From silicon to mechatronic systems<br>• Semiconductor components, assemblies, systems<br>• Challenges of electronic packaging technology (AVT)<br>• System integration in electronics: Requirements for AVT<br>• Methods and techniques of AVT<br>• Error patterns for assemblies and avoidance of errors<br>• Reliability analysis for printed circuit boards (PCBs)<br>• Reliability of Avionics<br>• COTS, ROTS, MOTS and the $F^3I$ concept<br>• Future challenges for electronics |
| **Literature** | - Skript zur Vorlesung<br><br>Hanke, H.-J.: Baugruppentechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994<br><br>Scheel, W.: Baugruppentechnologie der Elektronik.<br><br>Montage. Verlag Technik, 1999 |

| Course L1555: Reliability of avionics assemblies | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Examination Form** | Klausur |
| **Examination duration and scale** | 90 Minuten |
| **Lecturer** | Prof. Ralf God |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The objective of the lecture with the corresponding exercise is the acquisition of knowledge for development, electronic packaging technology and the production of electronic components for safety-critical applications. On an item, component and system level it is shown, how the specified safety objectives for electronics in aircraft can be achieved. Current challenges, such as availability of components, component counterfeiting and the use of components off-the-shelf (COTS) will be discussed:<br>• Survey of the role of electronics in aviation<br>• System levels: From silicon to mechatronic systems<br>• Semiconductor components, assemblies, systems<br>• Challenges of electronic packaging technology (AVT)<br>• System integration in electronics: Requirements for AVT<br>• Methods and techniques of AVT<br>• Error patterns for assemblies and avoidance of errors<br>• Reliability analysis for printed circuit boards (PCBs)<br>• Reliability of Avionics<br>• COTS, ROTS, MOTS and the $F^3I$ concept<br>• Future challenges for electronics |
| **Literature** | - Skript zur Vorlesung<br><br>Hanke, H.-J.: Baugruppentechnologie der Elektronik. Leiterplatten. Verlag Technik, 1994<br><br>Scheel, W.: Baugruppentechnologie der Elektronik.<br><br>Montage. Verlag Technik, 1999 |

| Course L0749: Reliability of Aircraft Systems | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Examination Form** | Klausur |
| **Examination duration and scale** | 90 Minuten |
| **Lecturer** | Prof. Frank Thielecke, Dr. Andreas Vahl, Dr. Uwe Wieczorek |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Functions of reliability and safety (regulations, certification requirements)<br>• Basics methods of reliability analysis (FMEA, fault tree, functional hazard assessment)<br>• Reliability analysis of electrical and mechanical systems |
| **Literature** | • CS 25.1309<br>• SAE ARP 4754<br>• SAE ARP 4761 |

## Module M1193: Cabin Systems Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Computer and communication technology in cabin electronics and avionics (L1557) | Lecture | 2 | 2 |
| Computer and communication technology in cabin electronics and avionics (L1558) | Recitation Section (small) | 1 | 1 |
| Model-Based Systems Engineering (MBSE) with SysML/UML (L1551) | Project-/problem-based Learning | 3 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Ralf God |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge in:<br>• Mathematics<br>• Mechanics<br>• Thermodynamics<br>• Electrical Engineering<br>• Control Systems<br><br>Previous knowledge in:<br>• Systems Engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to:<br>• describe the structure and operation of computer architectures<br>• explain the structure and operation of digital communication Networks<br>• explain architectures of cabin electronics, integrated modular avionics (IMA) and Aircraft Data Communication Network (ADCN)<br>• understand the approach of Model-Based Systems Engineering (MBSE) in the design of hardware and software-based cabin systems |
| *Skills* | Students are able to:<br>• understand, operate and maintain a Minicomputer<br>• build up a network communication and communicate with other network participants<br>• connect a minicomputer with a cabin management system (A380 CIDS) and communicate over a AFDX®-Network<br>• model system functions by means of formal languages SysML/UML and generate software code from the models<br>• execute software code on a minicomputer |
| **Personal Competence** | |
| *Social Competence* | Students are able to:<br>• elaborate partial results and merge with others to form a complete solution |
| *Autonomy* | Students are able to:<br>• organize and schedule their practical tasks |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 minutes |
| **Assignment for the Following Curricula** | Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Cabin Systems: Compulsory<br>International Management and Engineering: Specialisation II. Aviation Systems: 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: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory |

| Course L1557: Computer and communication technology in cabin electronics and avionics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Ralf God |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The objective of the lecture with the corresponding exercise is the acquisition of knowledge of computer and communication technology in electronic systems in the cabin and in aircraft. For the system engineer the strong interaction of software, mechanical and electronic system components nowadays requires a basic understanding of cabin electronics and avionics.<br><br>The course teaches the basics of design and functionality of computers and data networks. Subsequently it focuses on current principles and applications in integrated modular avionics (IMA), aircraft data communication networks (ADCN), cabin electronics and cabin networks:<br>• History of computer and network technology<br>• Layer model in computer technology<br>• Computer architectures (PC, IPC, Embedded Systems)<br>• BIOS, UEFI and operating system (OS)<br>• Programming languages (machine code and high-level languages)<br>• Applications and Application Programming Interfaces<br>• External interfaces (serial, USB, Ethernet)<br>• Layer model in network technology<br>• Network topologies<br>• Network components<br>• Bus access procedures<br>• Integrated Modular Avionics (IMA) and Aircraft Data Communication Networks (ADCN)<br>• Cabin electronics and cabin networks |
| **Literature** | - Skript zur Vorlesung<br>- Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003<br>- Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004<br>- Wüst, K.: Mikroprozessortechnik: Grundlagen, Architekturen und Programmierung von Mikroprozessoren, Mikrocontrollern und Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006 |

| Course L1558: Computer and communication technology in cabin electronics and avionics | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Ralf God |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The objective of the lecture with the corresponding exercise is the acquisition of knowledge of computer and communication technology in electronic systems in the cabin and in aircraft. For the system engineer the strong interaction of software, mechanical and electronic system components nowadays requires a basic understanding of cabin electronics and avionics.<br><br>The course teaches the basics of design and functionality of computers and data networks. Subsequently it focuses on current principles and applications in integrated modular avionics (IMA), aircraft data communication networks (ADCN), cabin electronics and cabin networks:<br>• History of computer and network technology<br>• Layer model in computer technology<br>• Computer architectures (PC, IPC, Embedded Systems)<br>• BIOS, UEFI and operating system (OS)<br>• Programming languages (machine code and high-level languages)<br>• Applications and Application Programming Interfaces<br>• External interfaces (serial, USB, Ethernet)<br>• Layer model in network technology<br>• Network topologies<br>• Network components<br>• Bus access procedures<br>• Integrated Modular Avionics (IMA) and Aircraft Data Communication Networks (ADCN)<br>• Cabin electronics and cabin networks |
| **Literature** | - Skript zur Vorlesung<br>- Schnabel, P.: Computertechnik-Fibel: Grundlagen Computertechnik, Mikroprozessortechnik, Halbleiterspeicher, Schnittstellen und Peripherie. Books on Demand; 1. Auflage, 2003<br>- Schnabel, P.: Netzwerktechnik-Fibel: Grundlagen, Übertragungstechnik und Protokolle, Anwendungen und Dienste, Sicherheit. Books on Demand; 1. Auflage, 2004<br>- Wüst, K.: Mikroprozessortechnik: Grundlagen, Architekturen und Programmierung von Mikroprozessoren, Mikrocontrollern und Signalprozessoren. Vieweg Verlag; 2. aktualisierte und erweiterte Auflage, 2006 |

| Course L1551: Model-Based Systems Engineering (MBSE) with SysML/UML | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Ralf God |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Objectives of the problem-oriented course are the acquisition of knowledge on system design using the formal languages SysML/UML, learning about tools for modeling and finally the implementation of a project with methods and tools of Model-Based Systems Engineering (MBSE) on a realistic hardware platform (e.g. Arduino®, Raspberry Pi®):<br>• What is a model?<br>• What is Systems Engineering?<br>• Survey of MBSE methodologies<br>• The modelling languages SysML /UML<br>• Tools for MBSE<br>• Best practices for MBSE<br>• Requirements specification, functional architecture, specification of a solution<br>• From model to software code<br>• Validation and verification: XiL methods<br>• Accompanying MBSE project |
| **Literature** | - Skript zur Vorlesung<br>- Weilkiens, T.: Systems Engineering mit SysML/UML: Modellierung, Analyse, Design. 2. Auflage, dpunkt.Verlag, 2008<br>- Holt, J., Perry, S.A., Brownsword, M.: Model-Based Requirements Engineering. Institution Engineering & Tech, 2011 |

## Specialization II. Mechatronics

### Module M0605: Computational Structural Dynamics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Computational Structural Dynamics (L0282) | Lecture | 3 | 4 |
| Computational Structural Dynamics (L0283) | Recitation Section (small) | 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 computational procedures for problems of structural dynamics.<br>+ explain the application of finite element programs to solve problems of structural dynamics.<br>+ specify problems of computational structural dynamics, to identify them in a given situation and to explain their mathematical and mechanical background. |
| *Skills* | Students are able to<br>+ model problems of structural dynamics.<br>+ select a suitable solution procedure for a given problem of structural dynamics.<br>+ apply computational procedures to solve problems of structural dynamics.<br>+ verify and critically judge results of computational structural dynamics. |
| **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>+ acquire independently knowledge to solve complex problems. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 2h |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory<br>Materials Science: Specialisation Modeling: Elective Compulsory<br>Mechatronics: Technical Complementary Course: 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 L0282: Computational Structural Dynamics

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Alexander Düster |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Motivation<br>2. Basics of dynamics<br>3. Time integration methods<br>4. Modal analysis<br>5. Fourier transform<br>6. Applications |
| **Literature** | [1] K.-J. Bathe, Finite-Elemente-Methoden, Springer, 2002.<br>[2] J.L. Humar, Dynamics of Structures, Taylor & Francis, 2012. |

| Course L0283: Computational Structural Dynamics | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Alexander Düster |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## 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 M0563: Robotics

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Robotics: Modelling and Control (L0168) | Lecture | 3 | 3 |
| Robotics: Modelling and Control (L1305) | Recitation Section (large) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Uwe Weltin |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals of electrical engineering<br><br>Broad knowledge of mechanics<br><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><br>Students can generate trajectories in various coordinate systems.<br><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><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** | 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: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: 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** | Dr. Martin Gomse, 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 (large) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Martin Gomse, Prof. Uwe Weltin |
| **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** / **Bonus** / **Form** / **Description**<br>No / 10 % / Excercises |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 minutes |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<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 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**<br>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><br>Scaling Rules<br><br>Lithography<br><br>Film deposition<br><br>Structuring and etching<br><br>Energy conversion and force generation<br><br>Electromagnetic Actuators<br><br>Reluctance motors<br><br>Piezoelectric actuators, bi-metal-actuator<br><br>Transducer principles<br><br>Signal detection and signal processing<br><br>Mechanical and physical sensors<br><br>Acceleration sensor, pressure sensor<br><br>Sensor arrays<br><br>System integration<br><br>Yield, test and reliability |
| **Literature** | M. Kasper: Mikrosystementwurf, Springer (2000)<br><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><br>Layout consideration<br><br>Electric, thermal and mechanical behaviour<br><br>Design aspects |
| **Literature** | Wird in der Veranstaltung bekannt gegeben |

## 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: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory |

### Course L0701: Vibration Theory

| | |
|---|---|
| **Typ** | Integrated Lecture |
| **Hrs/wk** | 4 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Lecturer** | Prof. Norbert Hoffmann |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | Linear and Nonlinear Single and Multiple Degree of Freedom Oscillations and Waves. |
| **Literature** | K. Magnus, K. Popp, W. Sextro: Schwingungen. Physikalische Grundlagen und mathematische Behandlung von Schwingungen. Springer Verlag, 2013. |

## Module M0768: Microsystems Technology in Theory and Practice

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Microsystems Technology (L0724) | Lecture | 2 | 4 |
| Microsystems Technology (L0725) | Project-/problem-based Learning | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Hoc Khiem Trieu |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics in physics, chemistry, mechanics and semiconductor technology |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able<br>• to present and to explain current fabrication techniques for microstructures and especially methods for the fabrication of microsensors and microactuators, as well as the integration thereof in more complex systems<br>• to explain in details operation principles of microsensors and microactuators and<br>• to discuss the potential and limitation of microsystems in application. |
| *Skills* | Students are capable<br>• to analyze the feasibility of microsystems,<br>• to develop process flows for the fabrication of microstructures and<br>• to apply them. |
| **Personal Competence** | |
| *Social Competence* | Students are able to prepare and perform their lab experiments in team work as well as to present and discuss the results in front of audience. |
| *Autonomy* | None |
| **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**: Studierenden führen in Kleingruppen ein Laborpraktikum durch. Jede Gruppe präsentiert und diskutiert die Theorie sowie die Ergebniise ihrer Labortätigkeit. vor dem gesamten Kurs. |
| **Examination** | Oral exam |
| **Examination duration and scale** | 30 min |
| **Assignment for the Following Curricula** | Electrical Engineering: Specialisation Nanoelectronics and Microsystems Technology: Elective Compulsory<br>Electrical Engineering: Specialisation Medical Technology: Elective Compulsory<br>International Management and Engineering: Specialisation II. Mechatronics: 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 |

| Course L0724: Microsystems Technology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Hoc Khiem Trieu |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Introduction (historical view, scientific and economic relevance, scaling laws)<br>• Semiconductor Technology Basics, Lithography (wafer fabrication, photolithography, improving resolution, next-generation lithography, nano-imprinting, molecular imprinting)<br>• Deposition Techniques (thermal oxidation, epitaxy, electroplating, PVD techniques: evaporation and sputtering; CVD techniques: APCVD, LPCVD, PECVD and LECVD; screen printing)<br>• Etching and Bulk Micromachining (definitions, wet chemical etching, isotropic etch with HNA, electrochemical etching, anisotropic etching with KOH/TMAH: theory, corner undercutting, measures for compensation and etch-stop techniques; plasma processes, dry etching: back sputtering, plasma etching, RIE, Bosch process, cryo process, XeF2 etching)<br>• Surface Micromachining and alternative Techniques (sacrificial etching, film stress, stiction: theory and counter measures; Origami microstructures, Epi-Poly, porous silicon, SOI, SCREAM process, LIGA, SU8, rapid prototyping)<br>• Thermal and Radiation Sensors (temperature measurement, self-generating sensors: Seebeck effect and thermopile; modulating sensors: thermo resistor, Pt-100, spreading resistance sensor, pn junction, NTC and PTC; thermal anemometer, mass flow sensor, photometry, radiometry, IR sensor: thermopile and bolometer)<br>• Mechanical Sensors (strain based and stress based principle, capacitive readout, piezoresistivity, pressure sensor: piezoresistive, capacitive and fabrication process; accelerometer: piezoresistive, piezoelectric and capacitive; angular rate sensor: operating principle and fabrication process)<br>• Magnetic Sensors (galvanomagnetic sensors: spinning current Hall sensor and magneto-transistor; magnetoresistive sensors: magneto resistance, AMR and GMR, fluxgate magnetometer)<br>• Chemical and Bio Sensors (thermal gas sensors: pellistor and thermal conductivity sensor; metal oxide semiconductor gas sensor, organic semiconductor gas sensor, Lambda probe, MOSFET gas sensor, pH-FET, SAW sensor, principle of biosensor, Clark electrode, enzyme electrode, DNA chip)<br>• Micro Actuators, Microfluidics and TAS (drives: thermal, electrostatic, piezo electric and electromagnetic; light modulators, DMD, adaptive optics, microscanner, microvalves: passive and active, micropumps, valveless micropump, electrokinetic micropumps, micromixer, filter, inkjet printhead, microdispenser, microfluidic switching elements, microreactor, lab-on-a-chip, microanalytics)<br>• MEMS in medical Engineering (wireless energy and data transmission, smart pill, implantable drug delivery system, stimulators: microelectrodes, cochlear and retinal implant; implantable pressure sensors, intelligent osteosynthesis, implant for spinal cord regeneration)<br>• Design, Simulation, Test (development and design flows, bottom-up approach, top-down approach, testability, modelling: multiphysics, FEM and equivalent circuit simulation; reliability test, physics-of-failure, Arrhenius equation, bath-tub relationship)<br>• System Integration (monolithic and hybrid integration, assembly and packaging, dicing, electrical contact: wire bonding, TAB and flip chip bonding; packages, chip-on-board, wafer-level-package, 3D integration, wafer bonding: anodic bonding and silicon fusion bonding; micro electroplating, 3D-MID) |
| **Literature** | M. Madou: Fundamentals of Microfabrication, CRC Press, 2002<br><br>N. Schwesinger: Lehrbuch Mikrosystemtechnik, Oldenbourg Verlag, 2009<br><br>T. M. Adams, R. A. Layton:Introductory MEMS, Springer, 2010<br><br>G. Gerlach; W. Dötzel: Introduction to microsystem technology, Wiley, 2008 |

| Course L0725: Microsystems Technology | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Hoc Khiem Trieu |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## 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 M1025: Fluidics

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Fluidics (L1256) | Lecture | 2 | 3 |
| Fluidics (L1371) | Project-/problem-based Learning | 1 | 2 |
| Fluidics (L1257) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Dieter Krause |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Good knowledge of mechanics (stereo statics, elastostatics, hydrostatics, kinematics and kinetics), fluid mechanics, and engineering design |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After passing the module students are able to<br>• explain structures and functionalities of hydrostatic, pneumatic, and hydrodynamic components,<br>• explain the interaction of hydraulic components in hydraulic systems,<br>• explain open and closed loop control of hydraulic systems,<br>• describe functioning and applications of hydrodynamic torque converters, brakes and clutches as well as centrifugal pumps and aggregates in plant technology |
| *Skills* | After passing the module students are able to<br>• analyse and assess hydraulic and pneumatic components and systems,<br>• design and dimension hydraulic systems for mechanical applications,<br>• perform numerical simulations of hydraulic systems based on abstract problem definitions,<br>• select and adapt pump characteristic curves for hydraulic systems<br>• dimension hydrodynamic torque converters and brakes for mechanical aggregates. |
| **Personal Competence** | |
| *Social Competence* | After passing the module students are able to<br>• discuss and present functional context in groups,<br>• organise teamwork autonomously. |
| *Autonomy* | After passing the module students are able to<br>• obtain necessary knowledge for the simulation. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes; **Bonus** None; **Form** Attestation; **Description** Simulation hydrostatischer Systeme |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory<br>International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Product Development: 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: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory |

| Course L1256: Fluidics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | **Lecture**<br><br>Hydrostatics<br><br>• physical fundamentals<br>• hydraulic fluids<br>• hydrostatic machines<br>• valves<br>• components<br>• hydrostatic transmissions<br>• examples from industry<br><br>Pneumatics<br><br>• generation of compressed air<br>• pneumatic motors<br>• Examples of use<br><br>Hydrodynamics<br><br>• physical fundamentals<br>• hydraulic continous-flow machines<br>• hydrodynamic transmissions<br>• interoperation of motor and transmission<br><br>**Exercise**<br><br>Hydrostatics<br><br>• reading and design of hydraulic diagrams<br>• dimensioning of hydrostatic traction and working drives<br>• performance calculation<br><br>Hydrodynamics<br><br>• calculation / dimensioning of hydrodynamic torque converters<br>• calculation / dimensioning of centrifugal pumps<br>• creating and reading of characteristic curves of pumps and systems<br><br>Field trip<br><br>• field trip to a regional company from the hydraulic industry.<br><br>**Exercise**<br><br>Numerical simulation of hydrostatic systems<br><br>• getting to know a numerical simulation environment for hydraulic systems<br>• transformation of a task into a simulation model<br>• simulation of common components<br>• variation of simulation parameters<br>• using simulations for system dimensioning and optimisation<br>• (partly) self-organised teamwork |
| **Literature** | Bücher<br><br>• Murrenhoff, H.: Grundlagen der Fluidtechnik - Teil 1: Hydraulik, Shaker Verlag, Aachen, 2011<br>• Murrenhoff, H.: Grundlagen der Fluidtechnik - Teil 2: Pneumatik, Shaker Verlag, Aachen, 2006<br>• Matthies, H.J. Renius, K.Th.: Einführung in die Ölhydraulik, Teubner Verlag, 2006<br>• Beitz, W., Grote, K.-H.: Dubbel - Taschenbuch für den Maschinenbau, Springer-Verlag, Berlin, aktuelle Auflage<br><br>Skript zur Vorlesung |

| Course L1371: Fluidics | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Dieter Krause |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1257: Fluidics | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Dieter Krause |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0832: Advanced Topics in Control

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Advanced Topics in Control (L0661) | Lecture | 2 | 3 |
| Advanced Topics in Control (L0662) | Recitation Section (small) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Herbert Werner |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | H-infinity optimal control, mixed-sensitivity design, linear matrix inequalities |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | • Students can explain the advantages and shortcomings of the classical gain scheduling approach<br>• They can explain the representation of nonlinear systems in the form of quasi-LPV systems<br>• They can explain how stability and performance conditions for LPV systems can be formulated as LMI conditions<br>• They can explain how gridding techniques can be used to solve analysis and synthesis problems for LPV systems<br>• They are familiar with polytopic and LFT representations of LPV systems and some of the basic synthesis techniques associated with each of these model structures<br><br>• Students can explain how graph theoretic concepts are used to represent the communication topology of multiagent systems<br>• They can explain the convergence properties of first order consensus protocols<br>• They can explain analysis and synthesis conditions for formation control loops involving either LTI or LPV agent models<br><br>• Students can explain the state space representation of spatially invariant distributed systems that are discretized according to an actuator/sensor array<br>• They can explain (in outline) the extension of the bounded real lemma to such distributed systems and the associated synthesis conditions for distributed controllers |
| *Skills* | • Students are capable of constructing LPV models of nonlinear plants and carry out a mixed-sensitivity design of gain-scheduled controllers; they can do this using polytopic, LFT or general LPV models<br>• They are able to use standard software tools (Matlab robust control toolbox) for these tasks<br><br>• Students are able to design distributed formation controllers for groups of agents with either LTI or LPV dynamics, using Matlab tools provided<br><br>• Students are able to design distributed controllers for spatially interconnected systems, using the Matlab MD-toolbox |
| **Personal Competence** | |
| *Social Competence* | Students can work in small groups and arrive at joint results. |
| *Autonomy* | Students are able to find required information in sources provided (lecture notes, literature, software documentation) and use it to solve given problems. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Oral exam |
| **Examination duration and scale** | 30 min |
| **Assignment for the Following Curricula** | Computer Science: Specialisation Intelligence Engineering: Elective Compulsory<br>Electrical Engineering: Specialisation Control and Power Systems Engineering: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Avionic Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory<br>Mechatronics: Specialisation System Design: Elective Compulsory<br>Mechatronics: Specialisation Intelligent Systems and Robotics: 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>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory |

| | |
|---|---|
| | Theoretical Mechanical Engineering: Core Qualification: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: Elective Compulsory |

| **Course L0661: Advanced Topics in Control** | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Herbert Werner |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Linear Parameter-Varying (LPV) Gain Scheduling<br><br>- Linearizing gain scheduling, hidden coupling<br>- Jacobian linearization vs. quasi-LPV models<br>- Stability and induced L2 norm of LPV systems<br>- Synthesis of LPV controllers based on the two-sided projection lemma<br>- Simplifications: controller synthesis for polytopic and LFT models<br>- Experimental identification of LPV models<br>- Controller synthesis based on input/output models<br>- Applications: LPV torque vectoring for electric vehicles, LPV control of a robotic manipulator<br><br>• Control of Multi-Agent Systems<br><br>- Communication graphs<br>- Spectral properties of the graph Laplacian<br>- First and second order consensus protocols<br>- Formation control, stability and performance<br>- LPV models for agents subject to nonholonomic constraints<br>- Application: formation control for a team of quadrotor helicopters<br><br>• Control of Spatially Interconnected Systems<br><br>- Multidimensional signals, l2 and L2 signal norm<br>- Multidimensional systems in Roesser state space form<br>- Extension of real-bounded lemma to spatially interconnected systems<br>- LMI-based synthesis of distributed controllers<br>- Spatial LPV control of spatially varying systems<br>- Applications: control of temperature profiles, vibration damping for an actuated beam |
| **Literature** | • Werner, H., Lecture Notes "Advanced Topics in Control"<br>• Selection of relevant research papers made available as pdf documents via StudIP |

| **Course L0662: Advanced Topics in Control** | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Herbert Werner |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0808: Finite Elements Methods

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Prof. 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 finite element method and are able to give an overview of the theoretical and methodical basis of the method. |
| *Skills* | The students are capable to handle engineering problems by formulating suitable finite elements, assembling the corresponding system matrices, and solving the resulting system of equations. |
| **Personal Competence** | |
| *Social Competence* | Students can work in small groups on specific problems to arrive at joint solutions. |
| *Autonomy* | The students are able to independently solve challenging computational problems and develop own finite element routines. Problems can be identified and the results are critically scrutinized. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>No / 20 % / Midterm / |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Civil Engineering: Core Qualification: Compulsory<br>Energy Systems: Core Qualification: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Mechatronics: 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>International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Product Development, Materials and Production: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Theoretical Mechanical Engineering: Core Qualification: Compulsory |

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

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

# Specialization II. Product Development and Production

## Module M1156: Systems Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Systems Engineering (L1547) | Lecture | 3 | 4 |
| Systems Engineering (L1548) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Ralf God |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge in:<br>• Mathematics<br>• Mechanics<br>• Thermodynamics<br>• Electrical Engineering<br>• Control Systems<br><br>Previous knowledge in:<br>• Aircraft Cabin Systems |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to:<br>• understand systems engineering process models, methods and tools for the development of complex Systems<br>• describe innovation processes and the need for technology Management<br>• explain the aircraft development process and the process of type certification for aircraft<br>• explain the system development process, including requirements for systems reliability<br>• identify environmental conditions and test procedures for airborne Equipment<br>• value the methodology of requirements-based engineering (RBE) and model-based requirements engineering (MBRE) |
| *Skills* | Students are able to:<br>• plan the process for the development of complex Systems<br>• organize the development phases and development Tasks<br>• assign required business activities and technical Tasks<br>• apply systems engineering methods and tools |
| **Personal Competence** | |
| *Social Competence* | Students are able to:<br>• understand their responsibilities within a development team and integrate themselves with their role in the overall process |
| *Autonomy* | Students are able to:<br>• interact and communicate in a development team which has distributed tasks |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 Minutes |
| **Assignment for the Following Curricula** | Aircraft Systems Engineering: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation II. Aviation Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory<br>Mechatronics: Specialisation System Design: Elective Compulsory<br>Mechatronics: Specialisation Intelligent Systems and Robotics: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Product Development: 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: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Aircraft Systems Engineering: Elective Compulsory |

| Course L1547: Systems Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Ralf God |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The objective of the lecture with the corresponding exercise is to accomplish the prerequisites for the development and integration of complex systems using the example of commercial aircraft and cabin systems. Competences in the systems engineering process, tools and methods is to be achieved. Regulations, guidelines and certification issues will be known.<br><br>Key aspects of the course are processes for innovation and technology management, system design, system integration and certification as well as tools and methods for systems engineering:<br>• Innovation processes<br>• IP-protection<br>• Technology management<br>• Systems engineering<br>• Aircraft program<br>• Certification issues<br>• Systems development<br>• Safety objectives and fault tolerance<br>• Environmental and operating conditions<br>• Tools for systems engineering<br>• Requirements-based engineering (RBE)<br>• Model-based requirements engineering (MBRE) |
| **Literature** | - Skript zur Vorlesung<br>- diverse Normen und Richtlinien (EASA, FAA, RTCA, SAE)<br>- Hauschildt, J., Salomo, S.: Innovationsmanagement. Vahlen, 5. Auflage, 2010<br>- NASA Systems Engineering Handbook, National Aeronautics and Space Administration, 2007<br>- Hinsch, M.: Industrielles Luftfahrtmanagement: Technik und Organisation luftfahrttechnischer Betriebe. Springer, 2010<br>- De Florio, P.: Airworthiness: An Introduction to Aircraft Certification. Elsevier Ltd., 2010<br>- Pohl, K.: Requirements Engineering. Grundlagen, Prinzipien, Techniken. 2. korrigierte Auflage, dpunkt.Verlag, 2008 |

| Course L1548: Systems Engineering | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Ralf God |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1170: Phenomena and Methods in Materials Science

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Experimental Methods for the Characterization of Materials (L1580) | Lecture | 2 | 3 |
| Phase equilibria and transformations (L1579) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Patrick Huber |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge in Materials Science, e.g. Werkstoffwissenschaft I/II |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students will be able to explain the properties of advanced materials along with their applications in technology, in particular metallic, ceramic, polymeric, semiconductor, modern composite materials (biomaterials) and nanomaterials. |
| *Skills* | The students will be able to select material configurations according to the technical needs and, if necessary, to design new materials considering architectural principles from the micro- to the macroscale. The students will also gain an overview on modern materials science, which enables them to select optimum materials combinations depending on the technical applications. |
| **Personal Competence** | |
| *Social Competence* | The students are able to present solutions to specialists and to develop ideas further. |
| *Autonomy* | The students are able to ...<br>• assess their own strengths and weaknesses.<br>• gather new necessary expertise by their own. |
| **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** | International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory<br>Materials Science: 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>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Materials Science: Elective Compulsory |

### Course L1580: Experimental Methods for the Characterization of Materials

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Patrick Huber |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Structural characterization by photons, neutrons and electrons (in particular X-ray and neutron scattering, electron microscopy, tomography)<br>• Mechanical and thermodynamical characterization methods (indenter measurements, mechanical compression and tension tests, specific heat measurements)<br>• Characterization of optical, electrical and magnetic properties (spectroscopy, electrical conductivity and magnetometry) |
| **Literature** | William D. Callister und David G. Rethwisch, Materialwissenschaften und Werkstofftechnik, Wiley&Sons, Asia (2011).<br>William D. Callister, Materials Science and Technology, Wiley& Sons, Inc. (2007). |

| Course L1579: Phase equilibria and transformations | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Jörg Weißmüller |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Fundamentals of statistical physics, formal structure of phenomenological thermodynamics, simple atomistic models and free-energy functions of solid solutions and compounds. Corrections due to nonlocal interaction (elasticity, gradient terms). Phase equilibria and alloy phase diagrams as consequence thereof. Simple atomistic considerations for interaction energies in metallic solid solutions. Diffusion in real systems. Kinetics of phase transformations for real-life boundary conditions. Partitioning, stability and morphology at solidification fronts. Order of phase transformations; glass transition. Phase transitions in nano- and microscale systems. |
| **Literature** | Wird im Rahmen der Lehrveranstaltung bekannt gegeben. |

## Module M1143: Mechanical Design Methodology

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Mechanical Design Methodology (L1523) | Lecture | 3 | 4 |
| Mechanical Design Methodology (L1524) | Recitation Section (small) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Josef Schlattmann |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Science-based working on product design considering targeted application of specific product design techniques |
| *Skills* | Creative handling of processes used for scientific preparation and formulation of complex product design problems / Application of various product design techniques following theoretical aspects. |
| **Personal Competence** | |
| *Social Competence* | |
| *Autonomy* | |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Oral exam |
| **Examination duration and scale** | 30 min |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation II. Product Development and Production: 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>Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory |

### Course L1523: Mechanical Design Methodology

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 78, Study Time in Lecture 42 |
| **Lecturer** | Prof. Josef Schlattmann |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Systematic reflection and analysis of the mechanical design process<br>• Process structuring in sections (task, functions, acting principles, design-elements and total construction) as well as levels (working-, controlling-, and deciding-levels)<br>• Creativity (basics, methods, practical application in mechatronics)<br>• Diverse methods applied as tools (function structure, GALFMOS, AEIOU method, GAMPFT, simulation tools, TRIZ)<br>• Evaluation and selection (technical-economical evaluation, preference matrix)<br>• Value analysis, cost-benefit analysis<br>• Low-noise design of technical products<br>• Project monitoring and leading (leading projects / employees, organisation in product development, creating ideas / responsibility and communication)<br>• Aesthetic product design (industrial design, colouring, specific examples / exercises) |
| **Literature** | • Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, K.-H.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoden und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007<br>• VDI-Richtlinien: 2206; 2221ff |

| Course L1524: Mechanical Design Methodology | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Josef Schlattmann |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Systematic reflection and analysis of the mechanical design process<br>• Process structuring in sections (task, functions, acting principles, design-elements and total construction) as well as levels (working-, controlling-, and deciding-levels)<br>• Creativity (basics, methods, practical application in mechatronics)<br>• Diverse methods applied as tools (function structure, GALFMOS, AEIOU method, GAMPFT, simulation tools, TRIZ)<br>• Evaluation and selection (technical-economical evaluation, preference matrix)<br>• Value analysis, cost-benefit analysis<br>• Low-noise design of technical products<br>• Project monitoring and leading (leading projects / employees, organisation in product development, creating ideas / responsibility and communication)<br>• Aesthetic product design (industrial design, colouring, specific examples / exercises) |
| **Literature** | • Pahl, G.; Beitz, W.; Feldhusen, J.; Grote, K.-H.: Konstruktionslehre: Grundlage erfolgreicher Produktentwicklung, Methoden und Anwendung, 7. Auflage, Springer Verlag, Berlin 2007<br>• VDI-Richtlinien: 2206; 2221ff |

## 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** / **Bonus** / **Form** / **Description**<br>No / 10 % / Presentation / 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 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 M1012: Laboratory of Logistics Engineering and Automatisation

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Laboratory Technical Logistics and Automatisation (L1462) | Seminar | 4 | 6 |

| | |
|---|---|
| **Module Responsible** | Prof. Jochen Kreutzfeldt |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Bachelor degree in logistics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students will acquire the following knowledge:<br>1. The students will learn various technical solutions for solving logistical problems using automatisation in daily practice.<br>2. The students know the necessary steps to implement a selected technical solution to automate logistical processes.<br>3. The students know the approaches and obstacles to implement technical solutions for automating logistical processes. |
| *Skills* | The students will acquire the following skills:<br>1. The students are able to select technical solutions of automatisation for logistical problems of warehousing, conveying, sorting, order picking and identifying and evaluate the implementability of the alternatives.<br>2. The students are able to implement selected solutions of automatisation in the model scale.<br>3. The students are able to estimate the implementation costs of selected solutions of automatisation. |
| **Personal Competence** | |
| *Social Competence* | The students will acquire the following social skills:<br>1. The students are able to develop technical solutions for logistical problems and implement them on a model scale within a group of students.<br>2. The technical solutions from the group can be jointly documented and presented to an audience.<br>3. The students are able to derive new ideas and improvements from the feedback received related to their developed solution proposals. |
| *Autonomy* | The students will acquire the following competencies:<br>1. Students are able, under the guidance of supervisors, to develop and implement independently solutions of automatisation for logistical problems of warehousing, conveying, sorting, order picking and identifying.<br>2. The students are able to evaluate their technical solutions and discuss the pros and cons. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written elaboration |
| **Examination duration and scale** | Prototype construction in laboratory with documentation (group work) |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation II. Logistics: Elective Compulsory<br>International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory |

| Course L1462: Laboratory Technical Logistics and Automatisation | |
|---|---|
| **Typ** | Seminar |
| **Hrs/wk** | 4 |
| **CP** | 6 |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Lecturer** | Prof. Jochen Kreutzfeldt |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The aim of the seminar is the practical introduction of students in various technical solutions to logistical problems. Above all, the guided development of own solutions is the core task in the laboratory. The problems and solutions will be drawn from the following logistic topics:<br>(1) warehousing<br>(2) conveying<br>(3) sorting<br>(4) order picking<br>(5) identifying<br>The students develop technical solutions in small groups for selected problems and implement them on a lab scale. The solutions are presented to an audience and advantages and disadvantages are discussed. The recorded feedback is then added to the model solution. |
| **Literature** | Dembowski, Klaus (2015): Raspberry Pi - Das technische Handbuch. Konfiguration, Hardware, Applikationserstellung. 2., erw. und überarb. Aufl. 2015. Wiesbaden: Springer Vieweg.<br>Follmann, Rüdiger (2014): Das Raspberry Pi Kompendium. 2014. Aufl. Berlin, Heidelberg: Springer Berlin Heidelberg (Xpert.press).<br>Griemert, Rudolf (2015): Fördertechnik. Auswahl und Berechnung von Elementen und Baugruppen. [S.l.]: Morgan Kaufmann.<br>Hompel, Michael ten; Büchter, Hubert; Franzke, Ulrich (2008): Identifikationssysteme und Automatisierung. [Intralogistik]. Berlin, Heidelberg: Springer.<br>Hompel, Michael ten; Beck, Maria; Sadowsky, Volker (2011): Kommissionierung. Materialflusssysteme 2 - Planung und Berechnung der Kommissionierung in der Logistik. Berlin [u.a.]: Springer.<br>Jodin, Dirk; Hompel, Michael ten (2012): Sortier- und Verteilsysteme. Grundlagen, Aufbau, Berechnung und Realisierung. 2. Aufl. Berlin: Springer Berlin.<br>Martin, Heinrich (2014): Transport- und Lagerlogistik. Planung, Struktur, Steuerung und Kosten von Systemen der Intralogistik. 9., vollst. überarb. u. akt. Aufl. 2014. Wiesbaden: Imprint: Springer Vieweg.<br>Purdum, Jack J. (2014): Beginning C for Arduino. Learn C programming for the Arduino. Second edition.: Springer Berlin.<br>McRoberts, Michael (2014): Beginning Arduino. Second edition.: Springer Berlin. |

## Module M0775: Ergonomics

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Ergonomics (L0653) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Dr. Armin Bossemeyer |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | |
| *Skills* | |
| **Personal Competence** | |
| *Social Competence* | |
| *Autonomy* | |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | None |
| **Examination** | Oral exam |
| **Examination duration and scale** | 30 min |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory |

| Course L0653: Ergonomics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Armin Bossemeyer |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | |
| **Literature** | |

## Module M0563: Robotics

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Robotics: Modelling and Control (L0168) | Lecture | 3 | 3 |
| Robotics: Modelling and Control (L1305) | Recitation Section (large) | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Uwe Weltin |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals of electrical engineering<br><br>Broad knowledge of mechanics<br><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><br>Students can generate trajectories in various coordinate systems.<br><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><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** | 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: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Robotics and Computer Science: 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** | Dr. Martin Gomse, 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 (large) |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Martin Gomse, Prof. Uwe Weltin |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0867: Production Planning & Control and Digital Enterprise

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| The Digital Enterprise (L0932) | Lecture | 2 | 2 |
| Production Planning and Control (L0929) | Lecture | 2 | 2 |
| Production Planning and Control (L0930) | Recitation Section (small) | 1 | 1 |
| Exercise: The Digital Enterprise (L0933) | Recitation Section (small) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Hermann Lödding |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals of Production and Quality Management |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can explain the contents of the module in detail and take a critical position to them. |
| *Skills* | Students are capable of choosing and applying models and methods from the module to industrial problems. |
| **Personal Competence** | |
| *Social Competence* | Students can develop joint solutions in mixed teams and present them to others. |
| *Autonomy* | - |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 180 Minuten |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: 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<br>Product Development, Materials and Production: Specialisation Product Development: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Production: 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 L0932: The Digital Enterprise

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Axel Friedewald |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Due to the developments of Industry 4.0, digitalization and interconnectivity become a strategic advantage for companies in the international competition. This lecture focuses on the relevant modules and enables the participants to evaluate current developments in this context. In particular, knowledge management, simulation, process modelling and virtual technologies are covered.<br><br>Content:<br>• Business Process Management and Data Modelling, Simulation<br>• Knowledge and Competence Management<br>• Process Management (PPC, Workflow Management)<br>• Computer Aided Planning (CAP) and NC-Programming<br>• Virtual Reality (VR) and Augmented Reality (AR)<br>• Computer Aided Quality Management (CAQ)<br>• Industry 4.0 |
| **Literature** | Scheer, A.-W.: ARIS - vom Geschäftsprozeß zum Anwendungssystem. Springer-Verlag, Berlin 4. Aufl. 2002<br><br>Schuh, G. et. al.: Produktionsplanung und -steuerung, Springer-Verlag. Berlin 3. Auflage 2006<br><br>Becker, J.; Luczak, H.: Workflowmanagement in der Produktionsplanung und -steuerung. Springer-Verlag, Berlin 2004<br><br>Pfeifer, T; Schmitt, R.: Masing Handbuch Qualitätsmanagement. Hanser-Verlag, München 5. Aufl. 2007<br><br>Kühn, W.: Digitale Fabrik. Hanser-Verlag, München 2006 |

| Course L0929: Production Planning and Control | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Hermann Lödding |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Models of Production and Inventory Management<br>• Production Programme Planning and Lot Sizing<br>• Order and Capacity Scheduling<br>• Selected Strategies of PPC<br>• Manufacturing Control<br>• Production Controlling<br>• Supply Chain Management |
| **Literature** | • Vorlesungsskript<br>• Lödding, H: Verfahren der Fertigungssteuerung, Springer 2008<br>• Nyhuis, P.; Wiendahl, H.-P.: Logistische Kennlinien, Springer 2002 |

| Course L0930: Production Planning and Control | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Hermann Lödding |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0933: Exercise: The Digital Enterprise | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Axel Friedewald |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | Siehe korrespondierende Vorlesung<br><br>See interlocking course |

## Module M1024: Methods of Integrated Product Development

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Integrated Product Development II (L1254) | Lecture | 3 | 3 |
| Integrated Product Development II (L1255) | Project-/problem-based Learning | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Dieter Krause |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge of Integrated product development and applying CAE systems |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After passing the module students are able to:<br>• explain technical terms of design methodology,<br>• describe essential elements of construction management,<br>• describe current problems and the current state of research of integrated product development. |
| *Skills* | After passing the module students are able to:<br>• select and apply proper construction methods for non-standardized solutions of problems as well as adapt new boundary conditions,<br>• solve product development problems with the assistance of a workshop based approach,<br>• choose and execute appropriate moderation techniques. |
| **Personal Competence** | |
| *Social Competence* | After passing the module students are able to:<br>• prepare and lead team meetings and moderation processes,<br>• work in teams on complex tasks,<br>• represent problems and solutions and advance ideas. |
| *Autonomy* | After passing the module students are able to:<br>• give a structured feedback and accept a critical feedback,<br>• implement the accepted feedback autonomous. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Oral exam |
| **Examination duration and scale** | 30 Minuten |
| **Assignment for the Following Curricula** | 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>Mechatronics: Specialisation System Design: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Product Development: 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: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory |

| Course L1254: Integrated Product Development II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Dieter Krause |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | **Lecture**<br><br>The lecture extends and enhances the learned content of the module “Integrated Product Development and lightweight design” and is based on the knowledge and skills acquired there.<br><br>Topics of the course include in particular:<br><br>• Methods of product development,<br>• Presentation techniques,<br>• Industrial Design,<br>• Design for variety<br>• Modularization methods,<br>• Design catalogs,<br>• Adapted QFD matrix,<br>• Systematic material selection,<br>• Assembly oriented design,<br><br>Construction management<br><br>• CE mark, declaration of conformity including risk assessment,<br>• Patents, patent rights, patent monitoring<br>• Project management (cost, time, quality) and escalation principles,<br>• Development management for mechatronics,<br>• Technical Supply Chain Management.<br><br>**Exercise (PBL)**<br><br>In the exercise the content presented in the lecture “Integrated Product Development II” and methods of product development and design management will be enhanced.<br><br>Students learn an independently moderated and workshop based approach through industry related practice examples to solve complex and currently existing issues in product development. They will learn the ability to apply important methods of product development and design management autonomous and acquire further expertise in the field of integrated product development. Besides personal skills, such as teamwork, guiding discussions and representing work results will be acquired through the workshop based structure of the event under its own planning and management. |
| **Literature** | • Andreasen, M.M., Design for Assembly, Berlin, Springer 1985.<br>• Ashby, M. F.: Materials Selection in Mechanical Design, München, Spektrum 2007.<br>• Beckmann, H.: Supply Chain Management, Berlin, Springer 2004.<br>• Hartmann, M., Rieger, M., Funk, R., Rath, U.: Zielgerichtet moderieren. Ein Handbuch für Führungskräfte, Berater und Trainer, Weinheim, Beltz 2007.<br>• Pahl, G., Beitz, W.: Konstruktionslehre, Berlin, Springer 2006.<br>• Roth, K.H.: Konstruieren mit Konstruktionskatalogen, Band 1-3, Berlin, Springer 2000.<br>• Simpson, T.W., Siddique, Z., Jiao, R.J.: Product Platform and Product Family Design. Methods and Applications, New York, Springer 2013. |

| Course L1255: Integrated Product Development II | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause |
| **Language** | DE |
| **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 M1025: Fluidics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fluidics (L1256) | Lecture | 2 | 3 |
| Fluidics (L1371) | Project-/problem-based Learning | 1 | 2 |
| Fluidics (L1257) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Dieter Krause |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Good knowledge of mechanics (stereo statics, elastostatics, hydrostatics, kinematics and kinetics), fluid mechanics, and engineering design |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After passing the module students are able to<br>• explain structures and functionalities of hydrostatic, pneumatic, and hydrodynamic components,<br>• explain the interaction of hydraulic components in hydraulic systems,<br>• explain open and closed loop control of hydraulic systems,<br>• describe functioning and applications of hydrodynamic torque converters, brakes and clutches as well as centrifugal pumps and aggregates in plant technology |
| *Skills* | After passing the module students are able to<br>• analyse and assess hydraulic and pneumatic components and systems,<br>• design and dimension hydraulic systems for mechanical applications,<br>• perform numerical simulations of hydraulic systems based on abstract problem definitions,<br>• select and adapt pump characteristic curves for hydraulic systems<br>• dimension hydrodynamic torque converters and brakes for mechanical aggregates. |
| **Personal Competence** | |
| *Social Competence* | After passing the module students are able to<br>• discuss and present functional context in groups,<br>• organise teamwork autonomously. |
| *Autonomy* | After passing the module students are able to<br>• obtain necessary knowledge for the simulation. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory**: Yes; **Bonus**: None; **Form**: Attestation; **Description**: Simulation hydrostatischer Systeme |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation II. Mechatronics: Elective Compulsory<br>International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory<br>Product Development, Materials and Production: Specialisation Product Development: 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: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory |

| Course L1256: Fluidics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Dieter Krause |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | **Lecture**<br><br>Hydrostatics<br><br>• physical fundamentals<br>• hydraulic fluids<br>• hydrostatic machines<br>• valves<br>• components<br>• hydrostatic transmissions<br>• examples from industry<br><br>Pneumatics<br><br>• generation of compressed air<br>• pneumatic motors<br>• Examples of use<br><br>Hydrodynamics<br><br>• physical fundamentals<br>• hydraulic continous-flow machines<br>• hydrodynamic transmissions<br>• interoperation of motor and transmission<br><br>**Exercise**<br><br>Hydrostatics<br><br>• reading and design of hydraulic diagrams<br>• dimensioning of hydrostatic traction and working drives<br>• performance calculation<br><br>Hydrodynamics<br><br>• calculation / dimensioning of hydrodynamic torque converters<br>• calculation / dimensioning of centrifugal pumps<br>• creating and reading of characteristic curves of pumps and systems<br><br>Field trip<br><br>• field trip to a regional company from the hydraulic industry.<br><br>**Exercise**<br><br>Numerical simulation of hydrostatic systems<br><br>• getting to know a numerical simulation environment for hydraulic systems<br>• transformation of a task into a simulation model<br>• simulation of common components<br>• variation of simulation parameters<br>• using simulations for system dimensioning and optimisation<br>• (partly) self-organised teamwork |
| **Literature** | Bücher<br><br>• Murrenhoff, H.: Grundlagen der Fluidtechnik - Teil 1: Hydraulik, Shaker Verlag, Aachen, 2011<br>• Murrenhoff, H.: Grundlagen der Fluidtechnik - Teil 2: Pneumatik, Shaker Verlag, Aachen, 2006<br>• Matthies, H.J. Renius, K.Th.: Einführung in die Ölhydraulik, Teubner Verlag, 2006<br>• Beitz, W., Grote, K.-H.: Dubbel - Taschenbuch für den Maschinenbau, Springer-Verlag, Berlin, aktuelle Auflage<br><br>Skript zur Vorlesung |

| Course L1371: Fluidics | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Dieter Krause |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1257: Fluidics | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Dieter Krause |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0808: Finite Elements Methods

**Courses**

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

| | |
|---|---|
| **Module Responsible** | Prof. 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 finite element method and are able to give an overview of the theoretical and methodical basis of the method. |
| *Skills* | The students are capable to handle engineering problems by formulating suitable finite elements, assembling the corresponding system matrices, and solving the resulting system of equations. |
| **Personal Competence** | |
| *Social Competence* | Students can work in small groups on specific problems to arrive at joint solutions. |
| *Autonomy* | The students are able to independently solve challenging computational problems and develop own finite element routines. Problems can be identified and the results are critically scrutinized. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>No / 20 % / Midterm / |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Civil Engineering: Core Qualification: Compulsory<br>Energy Systems: Core Qualification: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Aircraft Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory<br>Aircraft Systems Engineering: Specialisation Air Transportation Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Mechatronics: 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>International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory<br>Mechatronics: Core Qualification: Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Product Development, Materials and Production: Core Qualification: Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Technomathematics: Specialisation III. Engineering Science: Elective Compulsory<br>Theoretical Mechanical Engineering: Core Qualification: Compulsory |

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

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

## Module M0739: Factory Planning & Production Logistics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Factory Planning (L1445) | Lecture | 3 | 3 |
| Production Logistics (L1446) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Jochen Kreutzfeldt |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Bachelor degree in logistics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students will acquire the following knowledge:<br>1. The students know the latest trends and developments in the planning of factories.<br>2. The students can explain basic procedures of factory planning and are able to deploy these procedures while considering different conditions.<br>3. The students know different methods of factory planning and are able to deal critically with these methods. |
| *Skills* | The students will acquire the following skills:<br>1. The students are able to analyze factories and other material flow systems with regard to new development and the need for change of these logistical systems.<br>2. The students are able to plan and redesign factories and other material handling systems.<br>3. The students are able to develop procedures for the implementation of new and revised material flow systems. |
| **Personal Competence** | |
| *Social Competence* | The students will acquire the following social skills:<br>1. The students are able to develop plans for the development of new and improvement of existing material flow systems within a group.<br>2. The developed planning proposal from the group work can be documented and presented together.<br>3. The students are able to derive suggestions for improvement from the feedback on the planning proposals and can even provide constructive criticism themselves. |
| *Autonomy* | The students will acquire the following independent competencies:<br>1. The students can plan and re-design material flow systems using existing planning procedures.<br>2. The students can evaluate independently the strengths and weaknesses of several techniques for factory planning and choose appropriate methods in a given context.<br>3. The students are able to carry out autonomously new plans and transformations of material flow systems. |
| **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** | International Management and Engineering: Specialisation II. Logistics: Elective Compulsory<br>International Management and Engineering: Specialisation II. Product Development and Production: Elective Compulsory<br>Logistics, Infrastructure and Mobility: Specialisation Production and Logistics: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Product Development and Production: Elective Compulsory |

| Course L1445: Factory Planning | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Jochen Kreutzfeldt |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The lecture gives an introduction into the planning of factories and material flows. The students will learn process models and methods to plan new factories and improve existing material flow systems. The course includes three basic topics:<br>(1) Analysis of factory and material flow systems<br><br>(2) Development and re-planning of factory and material flow systems<br><br>(3) Implementation and realization of factory planning<br><br>The students are introduced into several different methods and models per topic. Practical examples and planning exercises deepen the methods and explain the application of factory planning.<br><br>The special requirements of factory planning in an international context are discussed. Specific requirements of Current trends and issues in the factory planning round off the lecture. |
| **Literature** | Bracht, Uwe; Wenzel, Sigrid; Geckler, Dieter (2018): Digitale Fabrik: Methoden und Praxisbeispiele. 2. Aufl.: Springer, Berlin.<br><br>Helbing, Kurt W. (2010): Handbuch Fabrikprojektierung. Berlin, Heidelberg: Springer Berlin Heidelberg.<br><br>Lotter, Bruno; Wiendahl, Hans-Peter (2012): Montage in der industriellen Produktion: Optimierte Abläufe, rationelle Automatisierung. 2. Aufl.: Springer, Berlin.<br><br>Müller, Egon; Engelmann, Jörg; Löffler, Thomas; Jörg, Strauch (2009): Energieeffiziente Fabriken planen und betreiben. Berlin, Heidelberg: Springer Berlin Heidelberg.<br><br>Schenk, Michael; Müller, Egon; Wirth, Siegfried (2014): Fabrikplanung und Fabrikbetrieb. Methoden für die wandlungsfähige, vernetzte und ressourceneffiziente Fabrik. 2. Aufl. Berlin [u.a.]: Springer Vieweg.<br><br>Wiendahl, Hans-Peter; Reichardt, Jürgen; Nyhuis, Peter (2014): Handbuch Fabrikplanung: Konzept, Gestaltung und Umsetzung wandlungsfähiger Produktionsstätten. 2. Aufl. Carl Hanser Verlag. |

| Course L1446: Production Logistics | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dipl.-Ing. Arnd Schirrmann |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Introduction: situation, significance and main innovation focuses of logistics in a production company, aspects of procurement, production, distribution and disposal logistics, production and transport networks<br>• Logistics as a production strategy: logistics-oriented method of working in a factory, throughput time, corporate strategy, structured networking, reducing complexity, integrated organization, integrated product and production logistics (IPPL)<br>• Logistics-compatible production and process structuring; logistics-compatible product, material flow, information and organizational structures<br>• Logistics-oriented production control: situation and development tendencies, logistics and cybernetics, market-oriented production planning, control, monitoring, PPS systems and production control, cybernetic production organization and control, production logistics control systems.<br>• Production logistics planning: key performance indicators, developing a production logistics concept, computerized aids to planning production logistics, IPPL functions, economic efficiency of logistics projects<br>• Production logistics controlling: production logistics and controlling, material flow-oriented cost transparency, cost controlling (process cost accounting, costs model in IPPL), process controlling (integrated production system, methods and tools, MEPOT.net method portal) |
| **Literature** | Pawellek, G.: Produktionslogistik: Planung - Steuerung - Controlling. Carl Hanser Verlag 2007 |

# Specialization II. Renewable Energy

## Module M0511: Electricity Generation from Wind and Hydro Power

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Renewable Energy Projects in Emerged Markets (L0014) | Project Seminar | 1 | 1 |
| Hydro Power Use (L0013) | Lecture | 1 | 1 |
| Wind Turbine Plants (L0011) | Lecture | 2 | 3 |
| Wind Energy Use - Focus Offshore (L0012) | Lecture | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Dr. Joachim Gerth |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Module: Technical Thermodynamics I,<br><br>Module: Technical Thermodynamics II,<br><br>Module: Fundamentals of Fluid Mechanics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | By ending this module students can explain in detail knowledge of wind turbines with a particular focus of wind energy use in offshore conditions and can critical comment these aspects in consideration of current developments. Furthermore, they are able to describe fundamentally the use of water power to generate electricity. The students reproduce and explain the basic procedure in the implementation of renewable energy projects in countries outside Europe.<br><br>Through active discussions of various topics within the seminar of the module, students improve their understanding and the application of the theoretical background and are thus able to transfer what they have learned in practice. |
| *Skills* | Students are able to apply the acquired theoretical foundations on exemplary water or wind power systems and evaluate and assess technically the resulting relationships in the context of dimensioning and operation of these energy systems. They can in compare critically the special procedure for the implementation of renewable energy projects in countries outside Europe with the in principle applied approach in Europe and can apply this procedure on exemplary theoretical projects. |
| **Personal Competence** | |
| *Social Competence* | Students can discuss scientific tasks subjet-specificly and multidisciplinary within a seminar. |
| *Autonomy* | Students can independently exploit sources in the context of the emphasis of the lecture material to clear the contents of the lecture and to acquire the particular knowledge about the subject area. |
| **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** | 3 hours written exam |
| **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 and Environmental Engineering: Specialisation Energy Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: 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>Renewable Energies: Core Qualification: Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

| Course L0014: Renewable Energy Projects in Emerged Markets | |
|---|---|
| **Typ** | Project Seminar |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Andreas Wiese |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction<br>◦ Development of renewable energies worldwide<br>▪ History<br>▪ Future markets<br>◦ Special challenges in new markets - Overview<br>2. Sample project wind farm Korea<br>◦ Survey<br>◦ Technical Description<br>◦ Project phases and characteristics<br>3. Funding and financing instruments for EE projects in new markets<br>◦ Overview funding opportunitie<br>◦ Overview countries with feed-in laws<br>◦ Major funding programs<br>4. CDM projects - why, how , examples<br>◦ Overview CDM process<br>◦ Examples<br>◦ Exercise CDM<br>5. Rural electrification and hybrid systems - an important future market for EE<br>◦ Rural Electrification - Introduction<br>◦ Types of Elektrizifierungsprojekten<br>◦ The role of the EEInterpretation of hybrid systems<br>◦ Project example: hybrid system Galapagos Islands<br>6. Tendering process for EE projects - examples<br>◦ South Africa<br>◦ Brazil<br>7. Selected projects from the perspective of a development bank - Wesley Urena Vargas, KfW Development Bank<br>◦ Geothermal<br>◦ Wind or CSP<br><br>Within the seminar, the various topics are actively discussed and applied to various cases of application. |
| **Literature** | Folien der Vorlesung |

| Course L0013: Hydro Power Use | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Stefan Achleitner |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Introduction, importance of water power in the national and global context<br>• Physical basics: Bernoulli's equation, usable height of fall, hydrological measures, loss mechanisms, efficiencies<br>• Classification of Hydropower: Flow and Storage hydropower, low and high pressure systems<br>• Construction of hydroelectric power plants: description of the individual components and their technical system interaction<br>• Structural engineering components; representation of dams, weirs, dams, power houses, computer systems, etc.<br>• Energy Technical Components: Illustration of the different types of hydraulic machinery, generators and grid connection<br>• Hydropower and the Environment<br>• Examples from practice |
| **Literature** | • Schröder, W.; Euler, G.; Schneider, K.: Grundlagen des Wasserbaus; Werner, Düsseldorf, 1999, 4. Auflage<br>• Quaschning, V.: Regenerative Energiesysteme: Technologie - Berechnung - Simulation; Carl Hanser, München, 2011, 7. Auflage<br>• Giesecke, J.; Heimerl, S.; Mosony, E.: Wasserkraftanlagen - Planung, Bau und Betrieb; Springer, Berlin, Heidelberg, 2009, 5. Auflage<br>• von König, F.; Jehle, C.: Bau von Wasserkraftanlagen - Praxisbezogene Planungsunterlagen; C. F. Müller, Heidelberg, 2005, 4. Auflage<br>• Strobl, T.; Zunic, F.: Wasserbau: Aktuelle Grundlagen - Neue Entwicklungen; Springer, Berlin, Heidelberg, 2006 |

| Course L0011: Wind Turbine Plants | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Rudolf Zellermann, Dr. Jochen Oexmann |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Historical development<br>• Wind: origins, geographic and temporal distribution, locations<br>• Power coefficient, rotor thrust<br>• Aerodynamics of the rotor<br>• Operating performance<br>• Power limitation, partial load, pitch and stall control<br>• Plant selection, yield prediction, economy<br>• Excursion |
| **Literature** | Gasch, R., Windkraftanlagen, 4. Auflage, Teubner-Verlag, 2005 |

| Course L0012: Wind Energy Use - Focus Offshore | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Martin Skiba |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Introduction, importance of offshore wind power generation, Specific requirements for offshore engineering<br>• Physical fundamentals for utilization of wind energy<br>• Design and operation of offshore wind turbines, presentation of different concepts of offshore wind turbines, representation of the individual system components and their system-technical relationships<br>• Foundation engineering, offshore site investigation, presentation of different concepts of offshore foundation structures, planning and fabrication of foundation structures<br>• Electrical infrastructure of an offshore wind farm, Inner Park cabling, offshore substation, grid connection<br>• Installation of offshore wind farms, installation techniques and auxiliary devices, construction logistics<br>• Development and planning of offshore wind farms<br>• Operation and optimization of offshore wind farms<br>• Day excursion |
| **Literature** | • Gasch, R.; Twele, J.: Windkraftanlagen - Grundlagen, Entwurf, Planung und Betrieb; Vieweg + Teubner, Stuttgart, 2007, 7. Auflage<br>• Molly, J. P.: Windenergie - Theorie, Anwendung, Messung; C. F. Müller, Heidel-berg, 1997, 3. Auflage<br>• Hau, E.: Windkraftanalagen; Springer, Berlin, Heidelberg, 2008, 4.Auflage<br>• Heier, S.: Windkraftanlagen - Systemauslegung, Integration und Regelung; Vieweg + Teubner, Stuttgart, 2009, 5. Auflage<br>• Jarass, L.; Obermair, G.M.; Voigt, W.: Windenergie: Zuverlässige Integration in die Energieversorgung; Springer, Berlin, Heidelberg, 2009, 2. Auflage |

## Module M0527: Marine Soil Technics

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Analysis of Maritime Systems (L0068) | Lecture | 2 | 2 |
| Analysis of Maritime Systems (L0069) | Recitation Section (small) | 1 | 1 |
| Offshore Geotechnical Engineering (L0067) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Dr. Joachim Gerth |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Knowledge in analysis and differential equations<br><br>Basics of maritime technology |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students can use the basic techniques for the analysis of offshore systems, including the related studies of the properties of the seabed, to provide an overview about that topic. Furthermore they can explain the associated content taking into account the specialist adjacent contexts. |
| *Skills* | Students are able to model and evaluate dynamic offshore systems. Consequently they are also able to think system-oriented and to break down complex system into subsystems . |
| **Personal Competence** | |
| *Social Competence* | none |
| *Autonomy* | Students can independently exploit sources , acquire the particular knowledge about the subject area and transform it to new questions. Furthermore, they can concrete assess their specific learning level within the exercise hours guided by teachers and can consequently define the further workflow. |
| **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** | 2 hours written exam |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory<br>Renewable Energies: Specialisation Wind Energy Systems: Elective Compulsory |

### Course L0068: Analysis of Maritime Systems

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Moustafa Abdel-Maksoud, Dr. Alexander Mitzlaff |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Hydrostatic analysis<br>◦ Buoyancy,<br>◦ Stability,<br>2. Hydrodynamic analysis<br>◦ Froude-Krylov force<br>◦ Morison's equation,<br>◦ Radiation and diffraction<br>◦ transparent/compact structures<br>3. Evaluation of offshore structures: Reliability techniques (security, reliability, disposability)<br>◦ Short-term statistics<br>◦ Long-term statistics and extreme events |
| **Literature** | • G. Clauss, E. Lehmann, C. Östergaard. Offshore Structures Volume I: Conceptual Design and Hydrodynamics. Springer Verlag Berlin, 1992<br>• E. V. Lewis (Editor), Principles of Naval Architecture ,SNAME, 1988<br>• Journal of Offshore Mechanics and Arctic Engineering<br>• Proceedings of International Conference on Offshore Mechanics and Arctic Engineering<br>• S. Chakrabarti (Ed.), Handbook of Offshore Engineering, Volumes 1-2, Elsevier, 2005<br>• S. K. Chakrabarti, Hydrodynamics of Offshore Structures , WIT Press, 2001 |

| Course L0069: Analysis of Maritime Systems | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Moustafa Abdel-Maksoud, Dr. Alexander Mitzlaff |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0067: Offshore Geotechnical Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Dr. Jan Dührkop |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Overview and Introduction Offshore Geotechnics<br>• Introduction to Soil Mechanics<br>• Offshore soil investigation<br>• Focus on cyclical effects<br>• Geotechnical design of offshore foundations<br>• Monopiles<br>• Jackets<br>• Heavyweight foundations<br>• Geotechnical preliminary exploration for the use of lift boats and platforms |
| **Literature** | • Randolph, M. and Gourvenec, S (2011): Offshore Geotechnical Engineering. Spon Press.<br>• Poulos H.G. (1988): Marine Geotechnics. Unwin Hyman, London<br>• BSH-Standard Baugrunderkundung für Offshore-Windenergieparks<br>• Lesny K. (2010): Foundations for Offshore Wind Turbines. VGE Verlag, Essen.<br>• EA-Pfähle (2012): Empfehlungen des Arbeitskreises Pfähle der DGGT. Ernst & Sohn, Berlin. |

## Module M0512: Use of Solar Energy

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Energy Meteorology (L0016) | Lecture | 1 | 1 |
| Energy Meteorology (L0017) | Recitation Section (small) | 1 | 1 |
| Collector Technology (L0018) | Lecture | 2 | 2 |
| Solar Power Generation (L0015) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Martin Kaltschmitt |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | none |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | With the completion of this module, students will be able to deal with technical foundations and current issues and problems in the field of solar energy and explain and evaulate these critically in consideration of the prior curriculum and current subject specific issues. In particular they can professionally describe the processes within a solar cell and explain the specific features of application of solar modules. Furthermore, they can provide an overview of the collector technology in solar thermal systems. |
| *Skills* | Students can apply the acquired theoretical foundations of exemplary energy systems using solar radiation. In this context, for example they can assess and evaluate potential and constraints of solar energy systems with respect to different geographical assumptions. They are able to dimension solar energy systems in consideration of technical aspects and given assumptions. Using module-comprehensive knowledge students can evalute the economic and ecologic conditions of these systems. They can select calculation methods within the radiation theory for these topics. |
| **Personal Competence** | |
| *Social Competence* | Students are able to discuss issues in the thematic fields in the renewable energy sector addressed within the module. |
| *Autonomy* | Students can independently exploit sources and acquire the particular knowledge about the subject area with respect to emphasis fo the lectures. Furthermore, with the assistance of lecturers, they can discrete use calculation methods for analysing and dimensioning solar energy systems. Based on this procedure they can concrete assess their specific learning level and can consequently define the further workflow. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 3 hours written exam |
| **Assignment for the Following Curricula** | Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory<br>Energy Systems: Specialisation Energy Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>Renewable Energies: Core Qualification: Compulsory<br>Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory |

| Course L0016: Energy Meteorology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Volker Matthias, Dr. Beate Geyer |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Introduction: radiation source Sun, Astronomical Foundations, Fundamentals of radiation<br>• Structure of the atmosphere<br>• Properties and laws of radiation<br>    ◦ Polarization<br>    ◦ Radiation quantities<br>    ◦ Planck's radiation law<br>    ◦ Wien's displacement law<br>    ◦ Stefan-Boltzmann law<br>    ◦ Kirchhoff's law<br>    ◦ Brightness temperature<br>    ◦ Absorption, reflection, transmission<br>• Radiation balance, global radiation, energy balance<br>• Atmospheric extinction<br>• Mie and Rayleigh scattering<br>• Radiative transfer<br>• Optical effects in the atmosphere<br>• Calculation of the sun and calculate radiation on inclined surfaces |
| **Literature** | • Helmut Kraus: Die Atmosphäre der Erde<br>• Hans Häckel: Meteorologie<br>• Grant W. Petty: A First Course in Atmosheric Radiation<br>• Martin Kaltschmitt, Wolfgang Streicher, Andreas Wiese: Renewable Energy<br>• Alexander Löw, Volker Matthias: Skript Optik Strahlung Fernerkundung |

| Course L0017: Energy Meteorology | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Beate Geyer |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0018: Collector Technology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Agis Papadopoulos |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Introduction: Energy demand and application of solar energy.<br>• Heat transfer in the solar thermal energy: conduction, convection, radiation.<br>• Collectors: Types, structure, efficiency, dimensioning, concentrated systems.<br>• Energy storage: Requirements, types.<br>• Passive solar energy: components and systems.<br>• Solar thermal low temperature systems: collector variants, construction, calculation.<br>• Solar thermal high temperature systems: Classification of solar power plants construction.<br>• Solar air conditioning. |
| **Literature** | • Vorlesungsskript.<br>• Kaltschmitt, Streicher und Wiese (Hrsg.). Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte, 5. Auflage, Springer, 2013.<br>• Stieglitz und Heinzel .Thermische Solarenergie: Grundlagen, Technologie, Anwendungen. Springer, 2012.<br>• Von Böckh und Wetzel. Wärmeübertragung: Grundlagen und Praxis, Springer, 2011.<br>• Baehr und Stephan. Wärme- und Stoffübertragung. Springer, 2009.<br>• de Vos. Thermodynamics of solar energy conversion. Wiley-VCH, 2008.<br>• Mohr, Svoboda und Unger. Praxis solarthermischer Kraftwerke. Springer, 1999. |

| Course L0015: Solar Power Generation | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Alf Mews, Martin Schlecht, Roman Fritsches-Baguhl |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction<br>2. Primary energy and consumption, available solar energy<br>3. Physics of the ideal solar cell<br>4. Light absorption PN junction characteristic values of the solar cell efficiency<br>5. Physics of the real solar cell<br>6. Charge carrier recombination characteristics, junction layer recombination, equivalent circuit<br>7. Increasing the efficiency<br>8. Methods for increasing the quantum yield, and reduction of recombination<br>9. Straight and tandem structures<br>10. Hetero-junction, Schottky, electrochemical, MIS and SIS-cell tandem cell<br>11. Concentrator<br>12. Concentrator optics and tracking systems<br>13. Technology and properties: types of solar cells, manufacture, single crystal silicon and gallium arsenide, polycrystalline silicon, and silicon thin film cells, thin-film cells on carriers (amorphous silicon, CIS, electrochemical cells)<br>14. Modules<br>15. Circuits |
| **Literature** | • A. Götzberger, B. Voß, J. Knobloch: Sonnenenergie: Photovoltaik, Teubner Studienskripten, Stuttgart, 1995<br>• A. Götzberger: Sonnenenergie: Photovoltaik : Physik und Technologie der Solarzelle, Teubner Stuttgart, 1994<br>• H.-J. Lewerenz, H. Jungblut: Photovoltaik, Springer, Berlin, Heidelberg, New York, 1995<br>• A. Götzberger: Photovoltaic solar energy generation, Springer, Berlin, 2005<br>• C. Hu, R. M. White: Solar Cells, Mc Graw Hill, New York, 1983<br>• H.-G. Wagemann: Grundlagen der photovoltaischen Energiewandlung: Solarstrahlung, Halbleitereigenschaften und Solarzellenkonzepte, Teubner, Stuttgart, 1994<br>• R. J. van Overstraeten, R.P. Mertens: Physics, technology and use of photovoltaics, Adam Hilger Ltd, Bristol and Boston, 1986<br>• B. O. Seraphin: Solar energy conversion Topics of applied physics V 01 31, Springer, Berlin, Heidelberg, New York, 1995<br>• P. Würfel: Physics of Solar cells, Principles and new concepts, Wiley-VCH, Weinheim 2005<br>• U. Rindelhardt: Photovoltaische Stromversorgung, Teubner-Reihe Umwelt, Stuttgart 2001<br>• V. Quaschning: Regenerative Energiesysteme, Hanser, München, 2003<br>• G. Schmitz: Regenerative Energien, Ringvorlesung TU Hamburg-Harburg 1994/95, Institut für Energietechnik |

## Module M0513: System Aspects of Renewable Energies

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage (L0021) | Lecture | 2 | 2 |
| Energy Trading (L0019) | Lecture | 1 | 1 |
| Energy Trading (L0020) | Recitation Section (small) | 1 | 1 |
| Deep Geothermal Energy (L0025) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Martin Kaltschmitt |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Module: Technical Thermodynamics I<br><br>Module: Technical Thermodynamics II |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to describe the processes in energy trading and the design of energy markets and can critically evaluate them in relation to current subject specific problems. Furthermore, they are able to explain the basics of thermodynamics of electrochemical energy conversion in fuel cells and can establish and explain the relationship to different types of fuel cells and their respective structure. Students can compare this technology with other energy storage options. In addition, students can give an overview of the procedure and the energetic involvement of deep geothermal energy. |
| *Skills* | Students can apply the learned knowledge of storage systems for excessive energy to explain for various energy systems different approaches to ensure a secure energy supply. In particular, they can plan and calculate domestic, commercial and industrial heating equipment using energy storage systems in an energy-efficient way and can assess them in relation to complex power systems. In this context, students can assess the potential and limits of geothermal power plants and explain their operating mode.<br><br>Furthermore, the students are able to explain the procedures and strategies for marketing of energy and apply it in the context of other modules on renewable energy projects. In this context they can unassistedly carry out analysis and evaluations of energie markets and energy trades. |
| **Personal Competence** | |
| *Social Competence* | Students are able to discuss issues in the thematic fields in the renewable energy sector addressed within the module. |
| *Autonomy* | Students can independently exploit sources , acquire the particular knowledge about the subject area and transform it to new questions. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 3 hours written exam |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>Renewable Energies: Core Qualification: Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory |

| Course L0021: Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Fröba |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction to electrochemical energy conversion<br>2. Function and structure of electrolyte<br>3. Low-temperature fuel cell<br>◦ Types<br>◦ Thermodynamics of the PEM fuel cell<br>◦ Cooling and humidification strategy<br>4. High-temperature fuel cell<br>◦ The MCFC<br>◦ The SOFC<br>◦ Integration Strategies and partial reforming<br>5. Fuels<br>◦ Supply of fuel<br>◦ Reforming of natural gas and biogas<br>◦ Reforming of liquid hydrocarbons<br>6. Energetic Integration and control of fuel cell systems |
| **Literature** | • Hamann, C.; Vielstich, W.: Elektrochemie 3. Aufl.; Weinheim: Wiley - VCH, 2003 |

| Course L0019: Energy Trading | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Michael Sagorje, Dr. Sven Orlowski |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Basic concepts and tradable products in energy markets<br>• Primary energy markets<br>• Electricity Markets<br>• European Emissions Trading Scheme<br>• Influence of renewable energy<br>• Real options<br>• Risk management<br><br>Within the exercise the various tasks are actively discussed and applied to various cases of application. |
| **Literature** | |

| Course L0020: Energy Trading | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Michael Sagorje, Dr. Sven Orlowski |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0025: Deep Geothermal Energy | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Ben Norden |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction to the deep geothermal use<br>2. Geological Basics I<br>3. Geological Basics II<br>4. Geology and thermal aspects<br>5. Rock Physical Aspects<br>6. Geochemical aspects<br>7. Exploration of deep geothermal reservoirs<br>8. Drilling technologies, piping and expansion<br>9. Borehole Geophysics<br>10. Underground system characterization and reservoir engineering<br>11. Microbiology and Upper-day system components<br>12. Adapted investment concepts, cost and environmental aspect |
| **Literature** | • Dipippo, R.: Geothermal Power Plants: Principles, Applications, Case Studies and Environmental Impact. Butterworth Heinemann; 3rd revised edition. (29. Mai 2012)<br>• www.geo-energy.org<br>• Edenhofer et al. (eds): Renewable Energy Sources and Climate Change Mitigation; Special Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2012.<br>• Kaltschmitt et al. (eds): Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. Springer, 5. Aufl. 2013.<br>• Kaltschmitt et al. (eds): Energie aus Erdwärme. Spektrum Akademischer Verlag; Auflage: 1999 (3. September 2001)<br>• Huenges, E. (ed.): Geothermal Energy Systems: Exploration, Development, and Utilization. Wiley-VCH Verlag GmbH & Co. KGaA; Auflage: 1. Auflage (19. April 2010) |

## Module M0518: Waste and Energy

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Waste Recycling Technologies (L0047) | Lecture | 2 | 2 |
| Waste Recycling Technologies (L0048) | Recitation Section (small) | 1 | 2 |
| Waste to Energy (L0049) | Project-/problem-based Learning | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Kerstin Kuchta |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of process engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to describe and explain in detail techniques, processes and concepts for treatment and energy recovery from wastes. |
| *Skills* | The students are able to select suitable processes for the treatment and energy recovery of wastes. They can evaluate the efforts and costs for processes and select economically feasible treatment Concepts. Students are able to evaluate alternatives even with incomplete information. Students are able to prepare systematic documentation of work results in form of reports, presentations and are able to defend their findings in a group. |
| **Personal Competence** | |
| *Social Competence* | Students can participate in subject-specific and interdisciplinary discussions, develop cooperated solutions and defend their own work results in front of others and promote the scientific development of collegues. Furthermore, they can give and accept professional constructive criticism. |
| *Autonomy* | Students can independently tap knowledge of the subject area and transform it to new questions. They are capable, in consultation with supervisors, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact. |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes, **Bonus** 20 %, **Form** Written elaboration, **Description** |
| **Examination** | Presentation |
| **Examination duration and scale** | PowerPoint presentation (10-15 minutes) |
| **Assignment for the Following Curricula** | Environmental Engineering: Specialisation Waste and Energy: Elective Compulsory<br>International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory<br>Joint European Master in Environmental Studies - Cities and Sustainability: Core Qualification: Compulsory<br>Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory |

| Course L0047: Waste Recycling Technologies | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Fundamentals on primary and secondary production of raw materials (steel, aluminum, phosphorous, copper, precious metals, rare metals)<br>• Use and demand of metals and minerals in industry and society<br>• collection systems and concepts<br>• quota and efficiency<br>• Advanced sorting technologies<br>• mechanical pretreatment<br>• advanced treatment<br>• Chemical analysis of Critical Materials in post-consumer products<br>• Analytical tools in Resource Management (Material Flow Analysis, Recycling Performance Indicators, Criticality Assessment, statistical analysis of uncertainties) |
| **Literature** | |

| Course L0048: Waste Recycling Technologies | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Fundamentals on primary and secondary production of raw materials (steel, aluminum, phosphorous, copper, precious metals, rare metals)<br>• Use and demand of metals and minerals in industry and society<br>• collection systems and concepts<br>• quota and efficiency<br>• Advanced sorting technologies<br>• mechanical pretreatment<br>• advanced treatment<br>• Chemical analysis of Critical Materials in post-consumer products<br>• Analytical tools in Resource Management (Material Flow Analysis, Recycling Performance Indicators, Criticality Assessment, statistical analysis of uncertainties) |
| **Literature** | |

| Course L0049: Waste to Energy | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Rüdiger Siechau |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Project-based lecture<br>• Introduction into the " Waste to Energy " consisting of:<br>◦ Thermal Process ( incinerator , RDF combustion )<br>◦ Biological processes ( Wet-/Dryfermentation )<br>◦ technology , energy , emissions, approval , etc.<br>• Group work<br>◦ design of systems/plants for energy recovery from waste<br>◦ The following points are to be processed :<br>▪ Input: waste ( fraction collection and transportation, current quantity , material flows , possible amount of development )<br>▪ Plant (design, process diagram , technology, energy production )<br>▪ Output ( energy quantity / type , by-products )<br>▪ Costs and revenues<br>▪ Climate and resource protection ( CO2 balance , substitution of primary raw materials / fossil fuels )<br>▪ Location and approval (infrastructure , expiration authorization procedure)<br>▪ Focus at the whole concept ( advantages, disadvantages , risks and opportunities , discussion )<br>• Grading: No Exam , but presentation of the results of the working group |
| **Literature** | **Literatur:**<br><br>Einführung in die Abfallwirtschaft; Martin Kranert, Klaus Cord-Landwehr (Hrsg.); Vieweg + Teubner Verlag; 2010<br><br>Powerpoint-Folien in Stud IP<br><br>**Literature:**<br>Introduction to Waste Management; Kranert Martin , Klaus Cord - Landwehr (Ed. ), Vieweg + Teubner Verlag , 2010<br><br>PowerPoint slides in Stud IP |

## Module M0749: Waste Treatment and Solid Matter Process Technology

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Solid Matter Process Technology for Biomass (L0052) | Lecture | 2 | 2 |
| Thermal Waste Treatment (L0320) | Lecture | 2 | 2 |
| Thermal Waste Treatment (L1177) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Kerstin Kuchta |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of<br>• thermo dynamics<br>• fluid dynamics<br>• chemistry |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can name, describe current issue and problems in the field of thermal waste treatment and particle process engineering and contemplate them in the context of their field.<br><br>The industrial application of unit operations as part of process engineering is explained by actual examples of waste incineration technologies and solid biomass processes. Compostion, particle sizes, transportation and dosing, drying and agglomeration of renewable resources and wastes are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, electricity , heat and mineral recyclables. |
| *Skills* | The students are able to select suitable processes for the treatment of wastes or raw material with respect to their characteristics and the process aims. They can evaluate the efforts and costs for processes and select economically feasible treatment concepts. |
| **Personal Competence** | |
| *Social Competence* | Students can<br>• respectfully work together as a team and discuss technical tasks<br>• participate in subject-specific and interdisciplinary discussions,<br>• develop cooperated solutions<br>• promote the scientific development and accept professional constructive criticism. |
| *Autonomy* | Students can independently tap knowledge of the subject area and transform it to new questions. They are capable, in consultation with supervisors, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact. |
| **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** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory<br>Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory<br>Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

| Course L0052: Solid Matter Process Technology for Biomass | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Werner Sitzmann |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The industrial application of unit operations as part of process engineering is explained by actual examples of solid biomass processes. Size reduction, transportation and dosing, drying and agglomeration of renewable resources are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, when making Btl - and WPC - products. Aspects of explosion protection and plant design complete the lecture. |
| **Literature** | Kaltschmitt M., Hartmann H. (Hrsg.): Energie aus Bioamsse, Springer Verlag, 2001, ISBN 3-540-64853-4<br><br>Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Schriftenreihe Nachwachsende Rohstoffe,<br><br>Fachagentur Nachwachsende Rohstoffe e.V. www.nachwachsende-rohstoffe.de<br><br>Bockisch M.: Nahrungsfette und -öle, Ulmer Verlag, 1993, ISBN 380000158175 |

| Course L0320: Thermal Waste Treatment | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Introduction, actual state-of-the-art of waste incineration, aims. legal background, reaction principals<br>• basics of incineration processes: waste composition, calorific value, calculation of air demand and flue gas composition<br>• Incineration techniques: grate firing, ash transfer, boiler<br>• Flue gas cleaning: Volume, composition, legal frame work and emission limits, dry treatment, scrubber, de-nox techniques, dioxin elimination, Mercury elimination<br>• Ash treatment: Mass, quality, treatment concepts, recycling, disposal |
| **Literature** | Thomé-Kozmiensky, K. J. (Hrsg.): Thermische Abfallbehandlung Bande 1-7. EF-Verlag für Energie- und Umwelttechnik, Berlin, 196 - 2013. |

| Course L1177: Thermal Waste Treatment | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0508: Fluid Mechanics and Ocean Energy

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Energy from the Ocean (L0002) | Lecture | 2 | 2 |
| Fluid Mechanics II (L0001) | Lecture | 2 | 4 |

| | |
|---|---|
| **Module Responsible** | Prof. Michael Schlüter |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Technische Thermodynamik I-II<br>Wärme- und Stoffübertragung |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are able to describe different applications of fluid mechanics for the field of Renewable Energies. They are able to use the fundamentals of fluid mechanics for calculations of certain engineering problems in the field of ocean energy. The students are able to estimate if a problem can be solved with an analytical solution and what kind of alternative possibilities are available (e.g. self-similarity, empirical solutions, numerical methods). |
| *Skills* | Students are able to use the governing equations of Fluid Dynamics for the design of technical processes. Especially they are able to formulate momentum and mass balances to optimize the hydrodynamics of technical processes. They are able to transform a verbal formulated message into an abstract formal procedure. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss a given problem in small groups and to develop an approach. They are able to solve a problem within a team, to prepare a poster with the results and to present the poster. |
| *Autonomy* | Students are able to define independently tasks for problems related to fluid mechanics. They are able to work out the knowledge that is necessary to solve the problem by themselves on the basis of the existing knowledge from the lecture. |
| **Workload in Hours** | Independent Study Time 124, Study Time in Lecture 56 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes · **Bonus** 10 % · **Form** Group discussion · **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 3h |
| **Assignment for the Following Curricula** | Energy Systems: Core Qualification: Elective Compulsory<br>International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory<br>Renewable Energies: Core Qualification: Compulsory<br>Theoretical Mechanical Engineering: Specialisation Energy Systems: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory |

| Course L0002: Energy from the Ocean | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Moustafa Abdel-Maksoud |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | 1. Introduction to ocean energy conversion<br>2. Wave properties<br>◦ Linear wave theory<br>◦ Nonlinear wave theory<br>◦ Irregular waves<br>◦ Wave energy<br>◦ Refraction, reflection and diffraction of waves<br>3. Wave energy converters<br>◦ Overview of the different technologies<br>◦ Methods for design and calculation<br>4. Ocean current turbine |
| **Literature** | • Cruz, J., Ocean wave energy, Springer Series in Green Energy and Technology, UK, 2008.<br>• Brooke, J., Wave energy conversion, Elsevier, 2003.<br>• McCormick, M.E., Ocean wave energy conversion, Courier Dover Publications, USA, 2013.<br>• Falnes, J., Ocean waves and oscillating systems, Cambridge University Press,UK, 2002.<br>• Charlier, R. H., Charles, W. F., Ocean energy. Tide and tidal Power. Berlin, Heidelberg, 2009.<br>• Clauss, G. F., Lehmann, E., Östergaard, C., Offshore Structures. Volume 1, Conceptual Design. Springer-Verlag, Berlin 1992 |

| Course L0001: Fluid Mechanics II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Schlüter |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Differential equations for momentum-, heat and mass transfer<br>• Examples for simplifications of the Navier-Stokes Equations<br>• Unsteady momentum transfer<br>• Free shear layer, turbulence and free jets<br>• Flow around particles - Solids Process Engineering<br>• Coupling of momentum and heat transfer - Thermal Process Engineering<br>• Rheology – Bioprocess Engineering<br>• Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering<br>• Flow threw porous structures - heterogeneous catalysis<br>• Pumps and turbines - Energy- and Environmental Process Engineering<br>• Wind- and Wave-Turbines - Renewable Energy<br>• Introduction into Computational Fluid Dynamics |
| **Literature** | 1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.<br>2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.<br>3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.<br>4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.<br>5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.<br>6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006.<br>7. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008.<br>8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007<br>9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009.<br>10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.<br>11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008.<br>12. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.<br>13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882. |

## Module M1294: Bioenergy

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Biofuels Process Technology (L0061) | Lecture | 1 | 1 |
| Biofuels Process Technology (L0062) | Recitation Section (small) | 1 | 1 |
| World Market for Commodities from Agriculture and Forestry (L1769) | Lecture | 1 | 1 |
| Thermal Biomass Utilization (L1767) | Lecture | 2 | 2 |
| Thermal Biomass Utilization (L2386) | Practical Course | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Martin Kaltschmitt |
| **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 reproduce an in-depth outline of energy production from biomass, aerobic and anaerobic waste treatment processes, the gained products and the treatment of produced emissions. |
| *Skills* | Students can apply the learned theoretical knowledge of biomass-based energy systems to explain relationships for different tasks, like dimesioning and design of biomass power plants. In this context, students are also able to solve computational tasks for combustion, gasification and biogas, biodiesel and bioethanol use. |
| **Personal Competence** | |
| *Social Competence* | Students can participate in discussions to design and evaluate energy systems using biomass as an energy source. |
| *Autonomy* | Students can independently exploit sources with respect to the emphasis of the lectures. They can choose and aquire the for the particular task useful knowledge. Furthermore, they can solve computational tasks of biomass-based energy systems independently with the assistance of the lecture. Regarding to this they can assess their specific learning level and can consequently define the further workflow. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 3 hours written exam |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Bioprocess Engineering: Specialisation C - Bioeconomic Process Engineering, Focus Energy and Bioprocess Technology: Elective Compulsory<br>Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory<br>Energy Systems: Specialisation Energy Systems: Elective Compulsory<br>International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory<br>Renewable Energies: Core Qualification: Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory |

| Course L0061: Biofuels Process Technology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Oliver Lüdtke |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • General introduction<br>• What are biofuels?<br>• Markets & trends<br>• Legal framework<br>• Greenhouse gas savings<br>• Generations of biofuels<br>  ◦ first-generation bioethanol<br>    ▪ raw materials<br>    ▪ fermentation distillation<br>  ◦ biobutanol / ETBE<br>  ◦ second-generation bioethanol<br>    ▪ bioethanol from straw<br>  ◦ first-generation biodiesel<br>    ▪ raw materials<br>    ▪ Production Process<br>    ▪ Biodiesel & Natural Resources<br>  ◦ HVO / HEFA<br>  ◦ second-generation biodiesel<br>    ▪ Biodiesel from Algae<br>• Biogas as fuel<br>  ◦ the first biogas generation<br>    ▪ raw materials<br>    ▪ fermentation<br>    ▪ purification to biomethane<br>  ◦ Biogas second generation and gasification processes<br>• Methanol / DME from wood and Tall oil © |
| **Literature** | • Skriptum zur Vorlesung<br>• Drapcho, Nhuan, Walker; Biofuels Engineering Process Technology<br>• Harwardt; Systematic design of separations for processing of biorenewables<br>• Kaltschmitt; Hartmann; Energie aus Biomasse: Grundlagen, Techniken und Verfahren<br>• Mousdale; Biofuels - Biotechnology, Chemistry and Sustainable Development<br>• VDI Wärmeatlas |

| Course L0062: Biofuels Process Technology | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Oliver Lüdtke |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Life Cycle Assessment<br>  ◦ Good example for the evaluation of CO2 savings potential by alternative fuels - Choice of system boundaries and databases<br>• Bioethanol production<br>  ◦ Application task in the basics of thermal separation processes (rectification, extraction) will be discussed. The focus is on a column design, including heat demand, number of stages, reflux ratio ...<br>• Biodiesel production<br>  ◦ Procedural options for solid / liquid separation, including basic equations for estimating power, energy demand, selectivity and throughput<br>• Biomethane production<br>  ◦ Chemical reactions that are relevant in the production of biofuels, including equilibria, activation energies, shift reactions |
| **Literature** | Skriptum zur Vorlesung |

| Course L1769: World Market for Commodities from Agriculture and Forestry | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Michael Köhl, Bernhard Chilla |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | 1) Markets for Agricultural Commodities<br>What are the major markets and how are markets functioning<br>Recent trends in world production and consumption.<br>World trade is growing fast. Logistics. Bottlenecks.<br>The major countries with surplus production<br>Growing net import requirements, primarily of China, India and many other countries.<br>Tariff and non-tariff market barriers. Government interferences.<br><br>2) Closer Analysis of Individual Markets<br>Thomas Mielke will analyze in more detail the global vegetable oil markets, primarily palm oil, soya oil, rapeseed oil, sunflower oil. Also the raw material (the oilseed) as well as the by-product (oilmeal) will be included. The major producers and consumers.<br>Vegetable oils and oilmeals are extracted from the oilseed. The importance of vegetable oils and animal fats will be highlighted, primarily in the food industry in Europe and worldwide. But in the past 15 years there have also been rapidly rising global requirements of oils & fats for non-food purposes, primarily as a feedstock for biodiesel but also in the chemical industry.<br>Importance of oilmeals as an animal feed for the production of livestock and aquaculture<br>Oilseed area, yields per hectare as well as production of oilseeds. Analysis of the major oilseeds worldwide. The focus will be on soybeans, rapeseed, sunflowerseed, groundnuts and cottonseed.<br>Regional differences in productivity. The winners and losers in global agricultural production.<br><br>3) Forecasts: Future Global Demand & Production of Vegetable Oils<br>Big challenges in the years ahead: Lack of arable land for the production of oilseeds, grains and other crops. Competition with livestock. Lack of water. What are possible solutions? Need for better education & management, more mechanization, better seed varieties and better inputs to raise yields.<br>The importance of prices and changes in relative prices to solve market imbalances (shortage situations as well as surplus situations). How does it work? Time lags.<br>Rapidly rising population, primarily the number of people considered “middle class” in the years ahead.<br>Higher disposable income will trigger changing diets in favour of vegetable oils and livestock products.<br>Urbanization. Today, food consumption per caput is partly still very low in many developing countries, primarily in Africa, some regions of Asia and in Central America. What changes are to be expected?<br>The myth and the realities of palm oil in the world of today and tomorrow.<br>Labour issues curb production growth: Some examples: 1) Shortage of labour in oil palm plantations in Malaysia. 2) Structural reforms overdue for the agriculture in India, China and other countries to become more productive and successful, thus improving the standard of living of smallholders. |
| **Literature** | Lecture material |

| Course L1767: Thermal Biomass Utilization | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Martin Kaltschmitt |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | Goal of this course is it to discuss the physical, chemical, and biological as well as the technical, economic, and environmental basics of all options to provide energy from biomass from a German and international point of view. Additionally different system approaches to use biomass for energy, aspects to integrate bioenergy within the energy system, technical and economic development potentials, and the current and expected future use within the energy system are presented.<br><br>The course is structured as follows:<br><br>• Biomass as an energy carrier within the energy system; use of biomass in Germany and world-wide, overview on the content of the course<br>• Photosynthesis, composition of organic matter, plant production, energy crops, residues, organic waste<br>• Biomass provision chains for woody and herbaceous biomass, harvesting and provision, transport, storage, drying<br>• Thermo-chemical conversion of solid biofuels<br>    ◦ Basics of thermo-chemical conversion<br>    ◦ Direct thermo-chemical conversion through combustion: combustion technologies for small and large scale units, electricity generation technologies, flue gas treatment technologies, ashes and their use<br>    ◦ Gasification: Gasification technologies, producer gas cleaning technologies, options to use the cleaned producer gas for the provision of heat, electricity and/or fuels<br>    ◦ Fast and slow pyrolysis: Technologies for the provision of bio-oil and/or for the provision of charcoal, oil cleaning technologies, options to use the pyrolysis oil and charcoal as an energy carrier as well as a raw material<br>• Physical-chemical conversion of biomass containing oils and/or fats: Basics, oil seeds and oil fruits, vegetable oil production, production of a biofuel with standardized characteristics (trans-esterification, hydrogenation, co-processing in existing refineries), options to use this fuel, options to use the residues (i.e. meal, glycerine)<br>• Bio-chemical conversion of biomass<br>    ◦ Basics of bio-chemical conversion<br>    ◦ Biogas: Process technologies for plants using agricultural feedstock, sewage sludge (sewage gas), organic waste fraction (landfill gas), technologies for the provision of bio methane, use of the digested slurry<br>    ◦ Ethanol production: Process technologies for feedstock containing sugar, starch or celluloses, use of ethanol as a fuel, use of the stillage |
| **Literature** | **Kaltschmitt, M.; Hartmann, H. (Hrsg.): Energie aus Biomasse; Springer, Berlin, Heidelberg, 2009, 2. Auflage** |

| Course L2386: Thermal Biomass Utilization | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Martin Kaltschmitt, Dr. Isabel Höfer |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The experiments of the practical lab course illustrate the different aspects of heat generation from biogenic solid fuels. First, different biomasses (e.g. wood, straw or agricultural residues) will be investigated; the focus will be on the calorific value of the biomass. Furthermore, the used biomass will be pelletized, the pellet properties analysed and a combustion test carried out on a pellet combustion system. The gaseous and solid pollutant emissions, especially the particulate matter emissions, are measured and the composition of the particulate matter is investigated in a further experiment. Another focus of the practical course is the consideration of options for the reduction of particulate matter emissions from biomass combustion. In the practical course, a method for particulate matter reduction will be developed and tested. All experiments will be evaluated and the results presented.<br><br>Within the practical lab course the students discuss different technical-scientific tasks, both subject-specifically and interdisciplinary. They<br>discuss various approaches to solving the problem and advise on the theoretical or practical implementation. |
| **Literature** | - Kaltschmitt, Martin; Hartmann, Hans; Hofbauer, Hermann: Energie aus Biomasse: Grundlagen, Techniken und Verfahren. 3. Auflage. Berlin Heidelberg: Springer Science & Business Media, 2016. -ISBN 978-3-662-47437-2<br>- Versuchsskript |

## Specialization II. Process Engineering and Biotechnology

### Module M0513: System Aspects of Renewable Energies

| Courses | | | |
|---|---|---|---|
| **Title** | **Typ** | **Hrs/wk** | **CP** |
| Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage (L0021) | Lecture | 2 | 2 |
| Energy Trading (L0019) | Lecture | 1 | 1 |
| Energy Trading (L0020) | Recitation Section (small) | 1 | 1 |
| Deep Geothermal Energy (L0025) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Martin Kaltschmitt |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Module: Technical Thermodynamics I<br><br>Module: Technical Thermodynamics II |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to describe the processes in energy trading and the design of energy markets and can critically evaluate them in relation to current subject specific problems. Furthermore, they are able to explain the basics of thermodynamics of electrochemical energy conversion in fuel cells and can establish and explain the relationship to different types of fuel cells and their respective structure. Students can compare this technology with other energy storage options. In addition, students can give an overview of the procedure and the energetic involvement of deep geothermal energy. |
| *Skills* | Students can apply the learned knowledge of storage systems for excessive energy to explain for various energy systems different approaches to ensure a secure energy supply. In particular, they can plan and calculate domestic, commercial and industrial heating equipment using energy storage systems in an energy-efficient way and can assess them in relation to complex power systems. In this context, students can assess the potential and limits of geothermal power plants and explain their operating mode.<br><br>Furthermore, the students are able to explain the procedures and strategies for marketing of energy and apply it in the context of other modules on renewable energy projects. In this context they can unassistedly carry out analysis and evaluations of energie markets and energy trades. |
| **Personal Competence** | |
| *Social Competence* | Students are able to discuss issues in the thematic fields in the renewable energy sector addressed within the module. |
| *Autonomy* | Students can independently exploit sources , acquire the particular knowledge about the subject area and transform it to new questions. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 3 hours written exam |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>Renewable Energies: Core Qualification: Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory |

| Course L0021: Fuel Cells, Batteries, and Gas Storage: New Materials for Energy Production and Storage | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Fröba |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction to electrochemical energy conversion<br>2. Function and structure of electrolyte<br>3. Low-temperature fuel cell<br>◦ Types<br>◦ Thermodynamics of the PEM fuel cell<br>◦ Cooling and humidification strategy<br>4. High-temperature fuel cell<br>◦ The MCFC<br>◦ The SOFC<br>◦ Integration Strategies and partial reforming<br>5. Fuels<br>◦ Supply of fuel<br>◦ Reforming of natural gas and biogas<br>◦ Reforming of liquid hydrocarbons<br>6. Energetic Integration and control of fuel cell systems |
| **Literature** | • Hamann, C.; Vielstich, W.: Elektrochemie 3. Aufl.; Weinheim: Wiley - VCH, 2003 |

| Course L0019: Energy Trading | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Michael Sagorje, Dr. Sven Orlowski |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | • Basic concepts and tradable products in energy markets<br>• Primary energy markets<br>• Electricity Markets<br>• European Emissions Trading Scheme<br>• Influence of renewable energy<br>• Real options<br>• Risk management<br><br>Within the exercise the various tasks are actively discussed and applied to various cases of application. |
| **Literature** | |

| Course L0020: Energy Trading | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Michael Sagorje, Dr. Sven Orlowski |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0025: Deep Geothermal Energy | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Ben Norden |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | 1. Introduction to the deep geothermal use<br>2. Geological Basics I<br>3. Geological Basics II<br>4. Geology and thermal aspects<br>5. Rock Physical Aspects<br>6. Geochemical aspects<br>7. Exploration of deep geothermal reservoirs<br>8. Drilling technologies, piping and expansion<br>9. Borehole Geophysics<br>10. Underground system characterization and reservoir engineering<br>11. Microbiology and Upper-day system components<br>12. Adapted investment concepts, cost and environmental aspect |
| **Literature** | • Dipippo, R.: Geothermal Power Plants: Principles, Applications, Case Studies and Environmental Impact. Butterworth Heinemann; 3rd revised edition. (29. Mai 2012)<br>• www.geo-energy.org<br>• Edenhofer et al. (eds): Renewable Energy Sources and Climate Change Mitigation; Special Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2012.<br>• Kaltschmitt et al. (eds): Erneuerbare Energien: Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. Springer, 5. Aufl. 2013.<br>• Kaltschmitt et al. (eds): Energie aus Erdwärme. Spektrum Akademischer Verlag; Auflage: 1999 (3. September 2001)<br>• Huenges, E. (ed.): Geothermal Energy Systems: Exploration, Development, and Utilization. Wiley-VCH Verlag GmbH & Co. KGaA; Auflage: 1. Auflage (19. April 2010) |

## Module M0874: Wastewater Systems

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Wastewater Systems - Collection, Treatment and Reuse (L0934) | Lecture | 2 | 2 |
| Wastewater Systems - Collection, Treatment and Reuse (L0943) | Recitation Section (large) | 1 | 1 |
| Advanced Wastewater Treatment (L0357) | Lecture | 2 | 2 |
| Advanced Wastewater Treatment (L0358) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Prof. Ralf Otterpohl |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Knowledge of wastewater management and the key processes involved in wastewater treatment. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to outline key areas of the full range of treatment systems in waste water management, as well as their mutual dependence for sustainable water protection. They can describe relevant economic, environmental and social factors. |
| *Skills* | Students are able to pre-design and explain the available wastewater treatment processes and the scope of their application in municipal and for some industrial treatment plants. |
| **Personal Competence** | |
| *Social Competence* | Social skills are not targeted in this module. |
| *Autonomy* | Students are in a position to work on a subject and to organize their work flow independently. They can also present on this subject. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Civil Engineering: Specialisation Structural Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Geotechnical Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Coastal Engineering: Elective Compulsory<br>Civil Engineering: Specialisation Water and Traffic: Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Energy and Environmental Engineering: Specialisation Environmental Engineering: Elective Compulsory<br>Environmental Engineering: Specialisation Water: Elective Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Water: Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Compulsory |

| Course L0934: Wastewater Systems - Collection, Treatment and Reuse | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | •Understanding the global situation with water and wastewater<br>•Regional planning and decentralised systems<br>•Overview on innovative approaches<br>•In depth knowledge on advanced wastewater treatment options for different situations, for end-of-pipe and reuse<br>•Mathematical Modelling of Nitrogen Removal<br>•Exercises with calculations and design |
| **Literature** | Henze, Mogens:<br>Wastewater Treatment: Biological and Chemical Processes, Springer 2002, 430 pages<br><br>George Tchobanoglous, Franklin L. Burton, H. David Stensel:<br>Wastewater Engineering: Treatment and Reuse, Metcalf & Eddy<br>McGraw-Hill, 2004 - 1819 pages |

| Course L0943: Wastewater Systems - Collection, Treatment and Reuse | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Ralf Otterpohl |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0357: Advanced Wastewater Treatment | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Joachim Behrendt |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Survey on advanced wastewater treatment<br><br>reuse of reclaimed municipal wastewater<br><br>Precipitation<br><br>Flocculation<br><br>Depth filtration<br><br>Membrane Processes<br><br>Activated carbon adsorption<br><br>Ozonation<br><br>"Advanced Oxidation Processes"<br><br>Disinfection |
| **Literature** | Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003<br><br>Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987<br><br>Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007<br><br>Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006<br><br>Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003 |

| Course L0358: Advanced Wastewater Treatment | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Joachim Behrendt |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Aggregate organic compounds (sum parameters)<br><br>Industrial wastewater<br><br>Processes for industrial wastewater treatment<br><br>Precipitation<br><br>Flocculation<br><br>Activated carbon adsorption<br><br>Recalcitrant organic compounds |
| **Literature** | Metcalf & Eddy, Wastewater Engineering: Treatment and Reuse, McGraw-Hill, Boston 2003<br><br>Wassertechnologie, H.H. Hahn, Springer-Verlag, Berlin 1987<br><br>Membranverfahren: Grundlagen der Modul- und Anlagenauslegung, T. Melin und R. Rautenbach, Springer-Verlag, Berlin 2007<br><br>Trinkwasserdesinfektion: Grundlagen, Verfahren, Anlagen, Geräte, Mikrobiologie, Chlorung, Ozonung, UV-Bestrahlung, Membranfiltration, Qualitätssicherung, W. Roeske, Oldenbourg-Verlag, München 2006<br><br>Organische Problemstoffe in Abwässern, H. Gulyas, GFEU, Hamburg 2003 |

## Module M0617: High Pressure Chemical Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| High Pressure Technique for Apparatus Engineering (L1278) | Lecture | 2 | 2 |
| Industrial Processes Under High Pressure (L0116) | Lecture | 2 | 2 |
| Advanced Separation Processes (L0094) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Dr. Monika Johannsen |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Fundamentals of Chemistry, Chemical Engineering, Fluid Process Engineering, Thermal Separation Processes, Thermodynamics, Heterogeneous Equilibria |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After a successful completion of this module, students can:<br>• explain the influence of pressure on the properties of compounds, phase equilibria, and production processes,<br>• describe the thermodynamic fundamentals of separation processes with supercritical fluids,<br>• exemplify models for the description of solid extraction and countercurrent extraction,<br>• discuss parameters for optimization of processes with supercritical fluids. |
| *Skills* | After successful completion of this module, students are able to:<br>• compare separation processes with supercritical fluids and conventional solvents,<br>• assess the application potential of high-pressure processes at a given separation task,<br>• include high pressure methods in a given multistep industrial application,<br>• estimate economics of high-pressure processes in terms of investment and operating costs,<br>• perform an experiment with a high pressure apparatus under guidance,<br>• evaluate experimental results,<br>• prepare an experimental protocol. |
| **Personal Competence** | |
| *Social Competence* | After successful completion of this module, students are able to:<br>• present a scientific topic from an original publication in teams of 2 and defend the contents together. |
| *Autonomy* | |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes, **Bonus** 15 %, **Form** Presentation, **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Bioprocess Engineering: Specialisation B - Industrial 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>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory |

| Course L1278: High Pressure Technique for Apparatus Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Arne Pietsch |
| **Language** | DE/EN |
| **Cycle** | SoSe |
| **Content** | 1. Basic laws and certification standards<br>2. Basics for calculations of pressurized vessels<br>3. Stress hypothesis<br>4. Selection of materials and fabrication processes<br>5. vessels with thin walls<br>6. vessels with thick walls<br>7. Safety installations<br>8. Safety analysis<br><br>Applications:<br><br>- subsea technology (manned and unmanned vessels)<br>- steam vessels<br>- heat exchangers<br>- LPG, LEG transport vessels |
| **Literature** | Apparate und Armaturen in der chemischen Hochdrucktechnik, Springer Verlag<br>Spain and Paauwe: High Pressure Technology, Vol. I und II, M. Dekker Verlag<br>AD-Merkblätter, Heumanns Verlag<br>Bertucco; Vetter: High Pressure Process Technology, Elsevier Verlag<br>Sherman; Stadtmuller: Experimental Techniques in High-Pressure Research, Wiley & Sons Verlag<br>Klapp: Apparate- und Anlagentechnik, Springer Verlag |

| Course L0116: Industrial Processes Under High Pressure | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Carsten Zetzl |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | Part I : Physical Chemistry and Thermodynamics<br>1. Introduction: Overview, achieving high pressure, range of parameters.<br><br>2. Influence of pressure on properties of fluids: P,v,T-behaviour, enthalpy, internal energy, entropy, heat capacity, viscosity, thermal conductivity, diffusion coefficients, interfacial tension.<br><br>3. Influence of pressure on heterogeneous equilibria: Phenomenology of phase equilibria<br><br>4. Overview on calculation methods for (high pressure) phase equilibria).<br>Influence of pressure on transport processes, heat and mass transfer.<br><br>Part II : High Pressure Processes<br>5. Separation processes at elevated pressures: Absorption, adsorption (pressure swing adsorption), distillation (distillation of air), condensation (liquefaction of gases)<br><br>6. Supercritical fluids as solvents: Gas extraction, cleaning, solvents in reacting systems, dyeing, impregnation, particle formation (formulation)<br><br>7. Reactions at elevated pressures. Influence of elevated pressure on biochemical systems: Resistance against pressure<br><br>**Part III : Industrial production**<br><br>8. Reaction : Haber-Bosch-process, methanol-synthesis, polymerizations; Hydrations, pyrolysis, hydrocracking; Wet air oxidation, supercritical water oxidation (SCWO)<br><br>9. Separation : Linde Process, De-Caffeination, Petrol and Bio-Refinery<br><br>10. Industrial High Pressure Applications in Biofuel and Biodiesel Production<br><br>11. Sterilization and Enzyme Catalysis<br><br>12. Solids handling in high pressure processes, feeding and removal of solids, transport within the reactor.<br><br>13. Supercritical fluids for materials processing.<br><br>14. Cost Engineering<br><br>Learning Outcomes:<br>After a successful completion of this module, the student should be able to<br><br>- understand of the influences of pressure on properties of compounds, phase equilibria, and production processes.<br><br>- Apply high pressure approches in the complex process design tasks<br><br>- Estimate Efficiency of high pressure alternatives with respect to investment and operational costs<br><br><br>Performance Record:<br>1. Presence (28 h)<br><br>2. Oral presentation of original scientific article (15 min) with written summary<br><br>3. Written examination and Case study<br><br>( 2+3 : 32 h Workload)<br><br>Workload:<br>60 hours total |
| **Literature** | Literatur:<br><br>Script: High Pressure Chemical Engineering.<br>G. Brunner: Gas Extraction. An Introduction to Fundamentals of Supercritical Fluids and the Application to Separation Processes. Steinkopff, Darmstadt, Springer, New York, 1994. |

| Course L0094: Advanced Separation Processes | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Monika Johannsen |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Introduction/Overview on Properties of Supercritical Fluids (SCF)and their Application in Gas Extraction Processes<br>• Solubility of Compounds in Supercritical Fluids and Phase Equilibrium with SCF<br>• Extraction from Solid Substrates: Fundamentals, Hydrodynamics and Mass Transfer<br>• Extraction from Solid Substrates: Applications and Processes (including Supercritical Water)<br>• Countercurrent Multistage Extraction: Fundamentals and Methods, Hydrodynamics and Mass Transfer<br>• Countercurrent Multistage Extraction: Applications and Processes<br>• Solvent Cycle, Methods for Precipitation<br>• Supercritical Fluid Chromatography (SFC): Fundamentals and Application<br>• Simulated Moving Bed Chromatography (SMB)<br>• Membrane Separation of Gases at High Pressures<br>• Separation by Reactions in Supercritical Fluids (Enzymes) |
| **Literature** | G. Brunner: Gas Extraction. An Introduction to Fundamentals of Supercritical Fluids and the Application to Separation Processes. Steinkopff, Darmstadt, Springer, New York, 1994. |

## Module M0914: Technical Microbiology

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Applied Molecular Biology (L0877) | Lecture | 2 | 3 |
| Technical Microbiology (L0999) | Lecture | 2 | 2 |
| Technical Microbiology (L1000) | Recitation Section (large) | 1 | 1 |

| | |
|---|---|
| **Module Responsible** | Dr. Anna Krüger |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Bachelor with basic knowledge in microbiology and genetics |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After successfully finishing this module, students are able<br>• to give an overview of genetic processes in the cell<br>• to explain the application of industrial relevant biocatalysts<br>• to explain and prove genetic differences between pro- and eukaryotes |
| *Skills* | After successfully finishing this module, students are able<br>• to explain and use advanced molecularbiological methods<br>• to recognize problems in interdisciplinary fields |
| **Personal Competence** | |
| *Social Competence* | Students are able to<br>• write protocols and PBL-summaries in teams<br>• to lead and advise members within a PBL-unit in a group<br>• develop and distribute work assignments for given problems |
| *Autonomy* | Students are able to<br>• search information for a given problem by themselves<br>• prepare summaries of their search results for the team<br>• make themselves familiar with new topics |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** / **Bonus** / **Form** / **Description**<br>No / 10 % / Excercises / Multiple Choice Aufgaben<br>No / 10 % / Group discussion / PBL Diskussionen |
| **Examination** | Written exam |
| **Examination duration and scale** | 60 min exam |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Environmental Engineering: Core Qualification: Elective Compulsory<br>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory |

| Course L0877: Applied Molecular Biology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Garabed Antranikian |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | Lecture and PBL<br><br>- Methods in genetics / molecular cloning<br><br>- Industrial relevance of microbes and their biocatalysts<br><br>- Biotransformation at extreme conditions<br><br>- Genomics<br><br>- Protein engineering techniques<br><br>- Synthetic biology |
| **Literature** | Relevante Literatur wird im Kurs zur Verfügung gestellt.<br><br>Grundwissen in Molekularbiologie, Genetik, Mikrobiologie und Biotechnologie erforderlich.<br><br>Lehrbuch: Brock - Mikrobiologie / Microbiology (Madigan et al.) |

| Course L0999: Technical Microbiology | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Dr. Anna Krüger |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • History of microbiology and biotechnology<br>• Enzymes<br>• Molecular biology<br>• Fermentation<br>• Downstream Processing<br>• Industrial microbiological processes<br>• Technical enzyme application<br>• Biological Waste Water treatment |
| **Literature** | **Microbiology**, 2013, Madigan, M., Martinko, J. M., Stahl, D. A., Clark, D. P. (eds.), formerly „Brock“, Pearson<br><br>**Industrielle Mikrobiologie**, 2012, Sahm, H., Antranikian, G., Stahmann, K.-P., Takors, R. (eds.) Springer Berlin, Heidelberg, New York, Tokyo.<br><br>**Angewandte Mikrobiologie**, 2005, Antranikian, G. (ed.), Springer, Berlin, Heidelberg, New York, Tokyo. |

| Course L1000: Technical Microbiology | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Dr. Christin Burkhardt |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M0749: Waste Treatment and Solid Matter Process Technology

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Solid Matter Process Technology for Biomass (L0052) | Lecture | 2 | 2 |
| Thermal Waste Treatment (L0320) | Lecture | 2 | 2 |
| Thermal Waste Treatment (L1177) | Recitation Section (large) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Kerstin Kuchta |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basics of<br>• thermo dynamics<br>• fluid dynamics<br>• chemistry |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can name, describe current issue and problems in the field of thermal waste treatment and particle process engineering and contemplate them in the context of their field.<br><br>The industrial application of unit operations as part of process engineering is explained by actual examples of waste incineration technologies and solid biomass processes. Compostion, particle sizes, transportation and dosing, drying and agglomeration of renewable resources and wastes are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, electricity , heat and mineral recyclables. |
| *Skills* | The students are able to select suitable processes for the treatment of wastes or raw material with respect to their characteristics and the process aims. They can evaluate the efforts and costs for processes and select economically feasible treatment concepts. |
| **Personal Competence** | |
| *Social Competence* | Students can<br>• respectfully work together as a team and discuss technical tasks<br>• participate in subject-specific and interdisciplinary discussions,<br>• develop cooperated solutions<br>• promote the scientific development and accept professional constructive criticism. |
| *Autonomy* | Students can independently tap knowledge of the subject area and transform it to new questions. They are capable, in consultation with supervisors, to assess their learning level and define further steps on this basis. Furthermore, they can define targets for new application-or research-oriented duties in accordance with the potential social, economic and cultural impact. |
| **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** | Civil Engineering: Specialisation Water and Traffic: Elective Compulsory<br>Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Energy and Environmental Engineering: Specialisation Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>International Management and Engineering: Specialisation II. Renewable Energy: Elective Compulsory<br>Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory<br>Process Engineering: Specialisation Chemical Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Process Engineering: Elective Compulsory<br>Process Engineering: Specialisation Environmental Process Engineering: Elective Compulsory<br>Water and Environmental Engineering: Specialisation Environment: Compulsory<br>Water and Environmental Engineering: Specialisation Cities: Elective Compulsory |

| Course L0052: Solid Matter Process Technology for Biomass | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Werner Sitzmann |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | The industrial application of unit operations as part of process engineering is explained by actual examples of solid biomass processes. Size reduction, transportation and dosing, drying and agglomeration of renewable resources are described as important unit operations when producing solid fuels and bioethanol, producing and refining edible oils, when making Btl - and WPC - products. Aspects of explosion protection and plant design complete the lecture. |
| **Literature** | Kaltschmitt M., Hartmann H. (Hrsg.): Energie aus Bioamsse, Springer Verlag, 2001, ISBN 3-540-64853-4<br><br>Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz, Schriftenreihe Nachwachsende Rohstoffe,<br><br>Fachagentur Nachwachsende Rohstoffe e.V. www.nachwachsende-rohstoffe.de<br><br>Bockisch M.: Nahrungsfette und -öle, Ulmer Verlag, 1993, ISBN 380000158175 |

| Course L0320: Thermal Waste Treatment | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | • Introduction, actual state-of-the-art of waste incineration, aims. legal background, reaction principals<br>• basics of incineration processes: waste composition, calorific value, calculation of air demand and flue gas composition<br>• Incineration techniques: grate firing, ash transfer, boiler<br>• Flue gas cleaning: Volume, composition, legal frame work and emission limits, dry treatment, scrubber, de-nox techniques, dioxin elimination, Mercury elimination<br>• Ash treatment: Mass, quality, treatment concepts, recycling, disposal |
| **Literature** | Thomé-Kozmiensky, K. J. (Hrsg.): Thermische Abfallbehandlung Bande 1-7. EF-Verlag für Energie- und Umwelttechnik, Berlin, 196 - 2013. |

| Course L1177: Thermal Waste Treatment | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Kerstin Kuchta |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1335: BIO II: Artificial Joint Replacement

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Artificial Joint Replacement (L1306) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Michael Morlock |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge of orthopedic and surgical techniques is recommended. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can name the different kinds of artificial limbs. |
| *Skills* | The students can explain the advantages and disadvantages of different kinds of endoprotheses. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss issues related to endoprothese with student mates and the teachers. |
| *Autonomy* | The students are able to acquire information on their own. They can also judge the information with respect to its credibility. |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Orientierungsstudium: 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 L1306: Artificial Joint Replacement

| | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Morlock |
| **Language** | DE |
| **Cycle** | SoSe |
| **Content** | Inhalt (deutsch)<br>1. EINLEITUNG (Bedeutung, Ziel, Grundlagen, allg. Geschichte des künstlichen Gelenker-satzes)<br>2. FUNKTIONSANALYSE (Der menschliche Gang, die menschliche Arbeit, die sportliche Aktivität)<br>3. DAS HÜFTGELENK (Anatomie, Biomechanik, Gelenkersatz Schaftseite und Pfannenseite, Evolution der Implantate)<br>4. DAS KNIEGELENK (Anatomie, Biomechanik, Bandersatz, Gelenkersatz femorale, tibiale und patelläre Komponenten)<br>5. DER FUß (Anatomie, Biomechanik, Gelen-kersatz, orthopädische Verfahren)<br>6. DIE SCHULTER (Anatomie, Biomechanik, Gelenkersatz)<br>7. DER ELLBOGEN (Anatomie, Biomechanik, Gelenkersatz)<br>8. DIE HAND (Anatomie, Biomechanik, Ge-lenkersatz)<br>9. TRIBOLOGIE NATÜRLICHER UND KÜNST-LICHER GELENKE (Korrosion, Reibung, Verschleiß) |
| **Literature** | Literatur:<br>Kapandji, I..: Funktionelle Anatomie der Gelenke (Band 1-4), Enke Verlag, Stuttgart, 1984.<br>Nigg, B., Herzog, W.: Biomechanics of the musculo-skeletal system, John Wiley&Sons, New York 1994<br>Nordin, M., Frankel, V.: Basic Biomechanics of the Musculoskeletal System, Lea&Febiger, Philadelphia, 1989.<br>Czichos, H.: Tribologiehandbuch, Vieweg, Wiesbaden, 2003.<br>Sobotta und Netter für Anatomie der Gelenke |

## Module M0896: Bioprocess and Biosystems Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Bioreactor Design and Operation (L1034) | Lecture | 2 | 2 |
| Bioreactors and Biosystems Engineering (L1037) | Project-/problem-based Learning | 1 | 2 |
| Biosystems Engineering (L1036) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. An-Ping Zeng |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Knowledge of bioprocess engineering and process engineering at bachelor level |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After completion of this module, participants will be able to:<br>• differentiate between different kinds of bioreactors and describe their key features<br>• identify and characterize the peripheral and control systems of bioreactors<br>• depict integrated biosystems (bioprocesses including up- and downstream processing)<br>• name different sterilization methods and evaluate those in terms of different applications<br>• recall and define the advanced methods of modern systems-biological approaches<br>• connect the multiple "omics"-methods and evaluate their application for biological questions<br>• recall the fundamentals of modeling and simulation of biological networks and biotechnological processes and to discuss their methods<br>• assess and apply methods and theories of genomics, transcriptomics, proteomics and metabolomics in order to quantify and optimize biological processes at molecular and process levels. |
| *Skills* | After completion of this module, participants will be able to:<br>• describe different process control strategies for bioreactors and chose them after analysis of characteristics of a given bioprocess<br>• plan and construct a bioreactor system including peripherals from lab to pilot plant scale<br>• adapt a present bioreactor system to a new process and optimize it<br>• develop concepts for integration of bioreactors into bioproduction processes<br>• combine the different modeling methods into an overall modeling approach, to apply these methods to specific problems and to evaluate the achieved results critically<br>• connect all process components of biotechnological processes for a holistic system view. |
| **Personal Competence** | |
| *Social Competence* | After completion of this module, participants will be able to debate technical questions in small teams to enhance the ability to take position to their own opinions and increase their capacity for teamwork.<br><br>The students can reflect their specific knowledge orally and discuss it with other students and teachers. |
| *Autonomy* | After completion of this module, participants will be able to solve a technical problem in teams of approx. 8-12 persons independently including a presentation of the results.<br>• |
| **Workload in Hours** | Independent Study Time 110, Study Time in Lecture 70 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory** Yes; **Bonus** 20 %; **Form** Presentation; **Description** |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 min |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core Qualification: Compulsory<br>Chemical and Bioprocess Engineering: Core Qualification: Compulsory<br>Environmental Engineering: Specialisation Biotechnology: Elective Compulsory<br>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>Renewable Energies: Specialisation Bioenergy Systems: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L1034: Bioreactor Design and Operation | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. An-Ping Zeng |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | **Design of bioreactors and peripheries:**<br>• reactor types and geometry<br>• materials and surface treatment<br>• agitation system design<br>• insertion of stirrer<br>• sealings<br>• fittings and valves<br>• peripherals<br>• materials<br>• standardization<br>• demonstration in laboratory and pilot plant<br>**Sterile operation:**<br>• theory of sterilisation processes<br>• different sterilisation methods<br>• sterilisation of reactor and probes<br>• industrial sterile test, automated sterilisation<br>• introduction of biological material<br>• autoclaves<br>• continuous sterilisation of fluids<br>• deep bed filters, tangential flow filters<br>• demonstration and practice in pilot plant<br>**Instrumentation and control:**<br>• temperature control and heat exchange<br>• dissolved oxygen control and mass transfer<br>• aeration and mixing<br>• used gassing units and gassing strategies<br>• control of agitation and power input<br>• pH and reactor volume, foaming, membrane gassing<br>**Bioreactor selection and scale-up:**<br>• selection criteria<br>• scale-up and scale-down<br>• reactors for mammalian cell culture<br>**Integrated biosystem:**<br>• interactions and integration of microorganisms, bioreactor and downstream processing<br>• Miniplant technologies<br>**Team work with presentation:**<br>• Operation mode of selected bioprocesses (e.g. fundamentals of batch, fed-batch and continuous cultivation) |
| **Literature** | • Storhas, Winfried, Bioreaktoren und periphere Einrichtungen, Braunschweig: Vieweg, 1994<br>• Chmiel, Horst, Bioprozeßtechnik; Springer 2011<br>• Krahe, Martin, Biochemical Engineering, Ullmann‘s Encyclopedia of Industrial Chemistry<br>• Pauline M. Doran, Bioprocess Engineering Principles, Second Edition, Academic Press, 2013<br>• Other lecture materials to be distributed |

<table>
<tr><th colspan="2">Course L1037: Bioreactors and Biosystems Engineering</th></tr>
<tr><td>Typ</td><td>Project-/problem-based Learning</td></tr>
<tr><td>Hrs/wk</td><td>1</td></tr>
<tr><td>CP</td><td>2</td></tr>
<tr><td>Workload in Hours</td><td>Independent Study Time 46, Study Time in Lecture 14</td></tr>
<tr><td>Lecturer</td><td>Prof. An-Ping Zeng</td></tr>
<tr><td>Language</td><td>EN</td></tr>
<tr><td>Cycle</td><td>SoSe</td></tr>
<tr><td>Content</td><td>Introduction to Biosystems Engineering (Exercise)<br><br>Experimental basis and methods for biosystems analysis<br>• Introduction to genomics, transcriptomics and proteomics<br>• More detailed treatment of metabolomics<br>• Determination of in-vivo kinetics<br>• Techniques for rapid sampling<br>• Quenching and extraction<br>• Analytical methods for determination of metabolite concentrations<br><br>Analysis, modelling and simulation of biological networks<br>• Metabolic flux analysis<br>• Introduction<br>• Isotope labelling<br>• Elementary flux modes<br>• Mechanistic and structural network models<br>• Regulatory networks<br>• Systems analysis<br>• Structural network analysis<br>• Linear and non-linear dynamic systems<br>• Sensitivity analysis (metabolic control analysis)<br><br>Modelling and simulation for bioprocess engineering<br>• Modelling of bioreactors<br>• Dynamic behaviour of bioprocesses<br>Selected projects for biosystems engineering<br>• Miniaturisation of bioreaction systems<br>• Miniplant technology for the integration of biosynthesis and downstream processin<br>• Technical and economic overall assessment of bioproduction processes</td></tr>
<tr><td>Literature</td><td>E. Klipp et al. Systems Biology in Practice, Wiley-VCH, 2006<br><br>R. Dohrn: Miniplant-Technik, Wiley-VCH, 2006<br><br>G.N. Stephanopoulos et. al.: Metabolic Engineering, Academic Press, 1998<br><br>I.J. Dunn et. al.: Biological Reaction Engineering, Wiley-VCH, 2003<br><br>Lecture materials to be distributed</td></tr>
</table>

| Course L1036: Biosystems Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. An-Ping Zeng |
| **Language** | EN |
| **Cycle** | SoSe |
| **Content** | **Introduction to Biosystems Engineering**<br><br>**Experimental basis and methods for biosystems analysis**<br>• Introduction to genomics, transcriptomics and proteomics<br>• More detailed treatment of metabolomics<br>• Determination of in-vivo kinetics<br>• Techniques for rapid sampling<br>• Quenching and extraction<br>• Analytical methods for determination of metabolite concentrations<br><br>**Analysis, modelling and simulation of biological networks**<br>• Metabolic flux analysis<br>• Introduction<br>• Isotope labelling<br>• Elementary flux modes<br>• Mechanistic and structural network models<br>• Regulatory networks<br>• Systems analysis<br>• Structural network analysis<br>• Linear and non-linear dynamic systems<br>• Sensitivity analysis (metabolic control analysis)<br><br>**Modelling and simulation for bioprocess engineering**<br>• Modelling of bioreactors<br>• Dynamic behaviour of bioprocesses<br><br>**Selected projects for biosystems engineering**<br>• Miniaturisation of bioreaction systems<br>• Miniplant technology for the integration of biosynthesis and downstream processin<br>• Technical and economic overall assessment of bioproduction processes |
| **Literature** | E. Klipp et al. Systems Biology in Practice, Wiley-VCH, 2006<br><br>R. Dohrn: Miniplant-Technik, Wiley-VCH, 2006<br><br>G.N. Stephanopoulos et. al.: Metabolic Engineering, Academic Press, 1998<br><br>I.J. Dunn et. al.: Biological Reaction Engineering, Wiley-VCH, 2003<br><br>Lecture materials to be distributed |

## Module M0519: Particle Technology and Solid Matter Process Technology

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Advanced Particle Technology II (L0051) | Project-/problem-based Learning | 1 | 1 |
| Advanced Particle Technology II (L0050) | Lecture | 2 | 2 |
| Experimental Course Particle Technology (L0430) | Practical Course | 3 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Stefan Heinrich |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge of solids processes and particle technology |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | After completion of the module the students will be able to describe and explain processes for solids processing in detail based on microprocesses on the particle level. |
| *Skills* | Students are able to choose process steps and apparatuses for the focused treatment of solids depending on the specific characteristics. They furthermore are able to adapt these processes and to simulate them. |
| **Personal Competence** | |
| *Social Competence* | Students are able to present results from small teamwork projects in an oral presentation and to discuss their knowledge with scientific researchers. |
| *Autonomy* | Students are able to analyze and solve problems regarding solid particles independently or in small groups. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | **Compulsory**: Yes; **Bonus**: None; **Form**: Written elaboration; **Description**: fünf Berichte (pro Versuch ein Bericht) à 5-10 Seiten |
| **Examination** | Written exam |
| **Examination duration and scale** | 120 minutes |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Bioprocess Engineering: Specialisation B - Industrial Bioprocess Engineering: Elective Compulsory<br>Energy and Environmental Engineering: Specialisation Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

### Course L0051: Advanced Particle Technology II

| | |
|---|---|
| **Typ** | Project-/problem-based Learning |
| **Hrs/wk** | 1 |
| **CP** | 1 |
| **Workload in Hours** | Independent Study Time 16, Study Time in Lecture 14 |
| **Lecturer** | Prof. Stefan Heinrich |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L0050: Advanced Particle Technology II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Stefan Heinrich |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | • Exercise in form of "Project based Learning"<br>• Agglomeration, particle size enlargement<br>• advanced particle size reduction<br>• Advanced theorie of fluid/particle flows<br>• CFD-methods for the simulation of disperse fluid/solid flows, Euler/Euler methids, Descrete Particle Modeling<br>• Treatment of simulation problems with distributed properties, solution of population balances |
| **Literature** | Schubert, H.; Heidenreich, E.; Liepe, F.; Neeße, T.: Mechanische Verfahrenstechnik. Deutscher Verlag für die Grundstoffindustrie, Leipzig, 1990.<br><br>Stieß, M.: Mechanische Verfahrenstechnik I und II. Springer Verlag, Berlin, 1992. |

| Course L0430: Experimental Course Particle Technology | |
|---|---|
| **Typ** | Practical Course |
| **Hrs/wk** | 3 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 48, Study Time in Lecture 42 |
| **Lecturer** | Prof. Stefan Heinrich |
| **Language** | DE/EN |
| **Cycle** | WiSe |
| **Content** | • Fluidization<br>• Agglomeration<br>• Granulation<br>• Drying<br>• Determination of mechanical properties of agglomerats |
| **Literature** | Schubert, H.; Heidenreich, E.; Liepe, F.; Neeße, T.: Mechanische Verfahrenstechnik. Deutscher Verlag für die Grundstoffindustrie, Leipzig, 1990.<br><br>Stieß, M.: Mechanische Verfahrenstechnik I und II. Springer Verlag, Berlin, 1992. |

## Module M0540: Transport Processes

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Multiphase Flows (L0104) | Lecture | 2 | 2 |
| Reactor Design Using Local Transport Processes (L0105) | Project-/problem-based Learning | 2 | 2 |
| Heat & Mass Transfer in Process Engineering (L0103) | Lecture | 2 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Michael Schlüter |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | All lectures from the undergraduate studies, especially mathematics, chemistry, thermodynamics, fluid mechanics, heat- and mass transfer. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | Students are able to:<br>• describe transport processes in single- and multiphase flows and they know the analogy between heat- and mass transfer as well as the limits of this analogy.<br>• explain the main transport laws and their application as well as the limits of application.<br>• describe how transport coefficients for heat- and mass transfer can be derived experimentally.<br>• compare different multiphase reactors like trickle bed reactors, pipe reactors, stirring tanks and bubble column reactors.<br>• are known. The Students are able to perform mass and energy balances for different kind of reactors. Further more the industrial application of multiphase reactors for heat- and mass transfer are known. |
| *Skills* | The students are able to:<br>• optimize multiphase reactors by using mass- and energy balances,<br>• use transport processes for the design of technical processes,<br>• to choose a multiphase reactor for a specific application. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss in international teams in english and develop an approach under pressure of time. |
| *Autonomy* | Students are able to define independently tasks, to solve the problem "design of a multiphase reactor". The knowledge that s necessary is worked out by the students themselves on the basis of the existing knowledge from the lecture. The students are able to decide by themselves what kind of equation and model is applicable to their certain problem. They are able to organize their own team and to define priorities for different tasks. |
| **Workload in Hours** | Independent Study Time 96, Study Time in Lecture 84 |
| **Credit points** | 6 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 15 min Presentation + 90 min multiple choice written examen |
| **Assignment for the Following Curricula** | Bioprocess Engineering: Core Qualification: Compulsory<br>Energy and Environmental Engineering: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>Renewable Energies: Specialisation Solar Energy Systems: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L0104: Multiphase Flows | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Schlüter |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Interfaces in MPF (boundary layers, surfactants)<br>• Hydrodynamics & pressure drop in Film Flows<br>• Hydrodynamics & pressure drop in Gas-Liquid Pipe Flows<br>• Hydrodynamics & pressure drop in Bubbly Flows<br>• Mass Transfer in Film Flows<br>• Mass Transfer in Gas-Liquid Pipe Flows<br>• Mass Transfer in Bubbly Flows<br>• Reactive mass Transfer in Multiphase Flows<br>• Film Flow: Application Trickle Bed Reactors<br>• Pipe Flow: Application Turbular Reactors<br>• Bubbly Flow: Application Bubble Column Reactors |
| **Literature** | Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.<br>Clift, R.; Grace, J.R.; Weber, M.E.: Bubbles, Drops and Particles, Academic Press, New York, 1978.<br>Fan, L.-S.; Tsuchiya, K.: Bubble Wake Dynamics in Liquids and Liquid-Solid Suspensions, Butterworth-Heinemann Series in Chemical Engineering, Boston, USA, 1990.<br>Hewitt, G.F.; Delhaye, J.M.; Zuber, N. (Ed.): Multiphase Science and Technology. Hemisphere Publishing Corp, Vol. 1/1982 bis Vol. 6/1992.<br>Kolev, N.I.: Multiphase flow dynamics. Springer, Vol. 1 and 2, 2002.<br>Levy, S.: Two-Phase Flow in Complex Systems. Verlag John Wiley & Sons, Inc, 1999.<br>Crowe, C.T.: Multiphase Flows with Droplets and Particles. CRC Press, Boca Raton, Fla, 1998. |

| Course L0105: Reactor Design Using Local Transport Processes | |
|---|---|
| **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 Schlüter |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | In this Problem-Based Learning unit the students have to design a multiphase reactor for a fast chemical reaction concerning optimal hydrodynamic conditions of the multiphase flow.<br><br>The four students in each team have to:<br><br>• collect and discuss material properties and equations for design from the literature,<br>• calculate the optimal hydrodynamic design,<br>• check the plausibility of the results critically,<br>• write an exposé with the results.<br><br>This exposé will be used as basis for the discussion within the oral group examen of each team. |
| **Literature** | see actual literature list in StudIP with recent published papers |

| Course L0103: Heat & Mass Transfer in Process Engineering | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Schlüter |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | • Introduction - Transport Processes in Chemical Engineering<br>• Molecular Heat- and Mass Transfer: Applications of Fourier's and Fick's Law<br>• Convective Heat and Mass Transfer: Applications in Process Engineering<br>• Unsteady State Transport Processes: Cooling & Drying<br>• Transport at fluidic Interfaces: Two Film, Penetration, Surface Renewal<br>• Transport Laws & Balance Equations with turbulence, sinks and sources<br>• Experimental Determination of Transport Coefficients<br>• Design and Scale Up of Reactors for Heat- and Mass Transfer<br>• Reactive Mass Transfer<br>• Processes with Phase Changes – Evaporization and Condensation<br>• Radiative Heat Transfer - Fundamentals<br>• Radiative Heat Transfer - Solar Energy |
| **Literature** | 1. Baehr, Stephan: Heat and Mass Transfer, Wiley 2002.<br>2. Bird, Stewart, Lightfood: Transport Phenomena, Springer, 2000.<br>3. John H. Lienhard: A Heat Transfer Textbook, Phlogiston Press, Cambridge Massachusetts, 2008.<br>4. Myers: Analytical Methods in Conduction Heat Transfer, McGraw-Hill, 1971.<br>5. Incropera, De Witt: Fundamentals of Heat and Mass Transfer, Wiley, 2002.<br>6. Beek, Muttzall: Transport Phenomena, Wiley, 1983.<br>7. Crank: The Mathematics of Diffusion, Oxford, 1995.<br>8. Madhusudana: Thermal Contact Conductance, Springer, 1996.<br>9. Treybal: Mass-Transfer-Operation, McGraw-Hill, 1987. |

## Module M0541: Process and Plant Engineering II

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Process and Plant Engineering II (L0097) | Lecture | 2 | 2 |
| Process and Plant Engineering II (L0098) | Recitation Section (large) | 1 | 2 |
| Process and Plant Engineering II (L1215) | Recitation Section (small) | 1 | 2 |

| | |
|---|---|
| **Module Responsible** | Prof. Mirko Skiborowski |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | unit operation of thermal and mechanical separation<br><br>chemical reactor engineering |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | students can:<br><br>-present process control concepts of apparatus and complex process plants<br><br>- classifyprocess models and model equations<br><br>- explain  numerical methods and their use in simulation tasks<br><br>- explain the solving strategy  of flowsheet simulation<br><br>- explain, present and discuss projects phases within the planning of processes<br><br>- present and explain the critical path method |
| *Skills* | students are capable of:<br><br>- formulation of targets of process control concepts and the translation into industrial practice<br><br>- design and evaluation of process control concepts and structures<br><br>- analyse the model structure ans parameters from the process simulation<br><br>- optimization of calculation sequence with respect to flowsheet simulation |
| **Personal Competence** | |
| *Social Competence* | students are capable of:<br><br>• develop solutions in heterogeneous small groups |
| *Autonomy* | students are capable of:<br><br>• taping new knowledge on a special subject by literature research |
| **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** | Bioprocess Engineering: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L0097: Process and Plant Engineering II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Mirko Skiborowski, Dr. Thomas Waluga |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | 1. **Process optimization**<br>Application areas<br>Formulation of constrained optimization<br>Solving strategy<br>Classes of optimization tasks<br>2. **Process control**<br>Typical control functions of equipment and apparatus in process engineering<br>Structures of control systems<br>Plantwide control<br>3. **Process Modeling**<br>Process models (steady state and dynamic behaviour)<br>Degrees of freedom<br>Examples from industrial practice<br>4. **Process simulation**<br>Structured approach<br>Numerical methods<br>Flowsheeting<br>Solution methods<br>Examples for experimental validation in industrial practice<br>Application of flowsheet simulation<br>5. **Plant design and construction**<br>Introduction<br>Industrial project implementation<br>Project execution: Applied aspects in industrial use<br>critical path method |
| **Literature** | Literatur (Planung und Bau von Produktionsanlagen):<br><br>G. Barnecker, Planung und Bau verfahrenstechnischer Anlagen, Springer Verlag, 2001<br><br>F.P. Helmus, Anlagenplanung, Wiley-VCH Verlag, Weinheim, 2003<br><br>E. Klapp, Apparate- und Anlagentechnik, Springer -Verlag, Berlin, 1980<br><br>P. Rinza, Projektmanagement: Planung, Überwachung und Steuerung von technischen<br><br>und nichttechnischen Vorhaben, Düsseldorf,VDI-Verlag, 1994<br><br>K. Sattler, W. Kasper, Verfahrentechnische Anlagen, Wiley-VCH Verlag, Weinheim, 2000<br><br>G.H. Vogel, Verfahrensentwicklung, Wiley-VCH, Weinheim, 2002<br><br>K.H. Weber, Inbetriebnahme verfahrenstechnischer Anlagen, VDI Verlag, Düsseldorf, 1996<br><br>E. Wegener, Montagegerechte Anlagenplanung, Wiley-VCH Verlag, Weinheim, 2003 |

| Course L0098: Process and Plant Engineering II | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Mirko Skiborowski, Dr. Thomas Waluga |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

| Course L1215: Process and Plant Engineering II | |
|---|---|
| **Typ** | Recitation Section (small) |
| **Hrs/wk** | 1 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 46, Study Time in Lecture 14 |
| **Lecturer** | Prof. Mirko Skiborowski, Dr. Thomas Waluga |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | See interlocking course |
| **Literature** | See interlocking course |

## Module M1334: BIO II: Biomaterials

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Biomaterials (L0593) | Lecture | 2 | 3 |

| | |
|---|---|
| **Module Responsible** | Prof. Michael Morlock |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | Basic knowledge of orthopedic and surgical techniques is recommended. |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students can describe the materials of the human body and the materials being used in medical engineering, and their fields of use. |
| *Skills* | The students can explain the advantages and disadvantages of different kinds of biomaterials. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss issues related to materials being present or being used for replacements with student mates and the teachers. |
| *Autonomy* | The students are able to acquire information on their own. They can also judge the information with respect to its credibility. |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Credit points** | 3 |
| **Course achievement** | None |
| **Examination** | Written exam |
| **Examination duration and scale** | 90 min |
| **Assignment for the Following Curricula** | International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>Materials Science: Specialisation Nano and Hybrid Materials: Elective Compulsory<br>Biomedical Engineering: Specialisation Artificial Organs and Regenerative Medicine: Elective Compulsory<br>Biomedical Engineering: Specialisation Implants and Endoprostheses: Compulsory<br>Biomedical Engineering: Specialisation Medical Technology and Control Theory: Elective Compulsory<br>Biomedical Engineering: Specialisation Management and Business Administration: Elective Compulsory<br>Theoretical Mechanical Engineering: Technical Complementary Course: Elective Compulsory<br>Theoretical Mechanical Engineering: Specialisation Bio- and Medical Technology: Elective Compulsory |

| Course L0593: Biomaterials | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 3 |
| **Workload in Hours** | Independent Study Time 62, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Morlock |
| **Language** | EN |
| **Cycle** | WiSe |
| **Content** | Topics to be covered include:<br><br>1. Introduction (Importance, nomenclature, relations)<br><br>2. Biological materials<br><br>2.1 Basics (components, testing methods)<br><br>2.2 Bone (composition, development, properties, influencing factors)<br><br>2.3 Cartilage (composition, development, structure, properties, influencing factors)<br><br>2.4 Fluids (blood, synovial fluid)<br><br>3 Biological structures<br><br>3.1 Menisci of the knee joint<br><br>3.2 Intervertebral discs<br><br>3.3 Teeth<br><br>3.4 Ligaments<br><br>3.5 Tendons<br><br>3.6 Skin<br><br>3.7 Nervs<br><br>3.8 Muscles<br><br>4. Replacement materials<br><br>4.1 Basics (history, requirements, norms)<br><br>4.2 Steel (alloys, properties, reaction of the body)<br><br>4.3 Titan (alloys, properties, reaction of the body)<br><br>4.4 Ceramics and glas (properties, reaction of the body)<br><br>4.5 Plastics (properties of PMMA, HDPE, PET, reaction of the body)<br><br>4.6 Natural replacement materials<br><br>Knowledge of composition, structure, properties, function and changes/adaptations of biological and technical materials (which are used for replacements in-vivo). Acquisition of basics for theses work in the area of biomechanics. |
| **Literature** | Hastings G and Ducheyne P.: Natural and living biomaterials. Boca Raton: CRC Press, 1984.<br><br>Williams D.: Definitions in biomaterials. Oxford: Elsevier, 1987.<br><br>Hastings G.: Mechanical properties of biomaterials: proceedings held at Keele University, September 1978. New York: Wiley, 1998.<br><br>Black J.: Orthopaedic biomaterials in research and practice. New York: Churchill Livingstone, 1988.<br><br>Park J. Biomaterials: an introduction. New York: Plenum Press, 1980.<br><br>Wintermantel, E. und Ha, S.-W : Biokompatible Werkstoffe und Bauweisen. Berlin, Springer, 1996. |

## Module M0542: Fluid Mechanics in Process Engineering

**Courses**

| Title | Typ | Hrs/wk | CP |
|---|---|---|---|
| Applications of Fluid Mechanics in Process Engineering (L0106) | Recitation Section (large) | 2 | 2 |
| Fluid Mechanics II (L0001) | Lecture | 2 | 4 |

| | |
|---|---|
| **Module Responsible** | Prof. Michael Schlüter |
| **Admission Requirements** | None |
| **Recommended Previous Knowledge** | • Mathematics I-III<br>• Fundamentals in Fluid Mechanics<br>• Technical Thermodynamics I-II<br>• Heat- and Mass Transfer |
| **Educational Objectives** | After taking part successfully, students have reached the following learning results |
| **Professional Competence** | |
| *Knowledge* | The students are able to describe different applications of fluid mechanics in Process Engineering, Bioprocess Engineering, Energy- and Environmental Process Engineering and Renewable Energies. They are able to use the fundamentals of fluid mechanics for calculations of certain engineering problems. The students are able to estimate if a problem can be solved with an analytical solution and what kind of alternative possibilities are available (e.g. self-similarity in an example of free jets, empirical solutions in an example with the Forchheimer equation, numerical methods in an example of Large Eddy Simulation. |
| *Skills* | Students are able to use the governing equations of Fluid Dynamics for the design of technical processes. Especially they are able to formulate momentum and mass balances to optimize the hydrodynamics of technical processes. They are able to transform a verbal formulated message into an abstract formal procedure. |
| **Personal Competence** | |
| *Social Competence* | The students are able to discuss a given problem in small groups and to develop an approach. |
| *Autonomy* | Students are able to define independently tasks for problems related to fluid mechanics. They are able to work out the knowledge that is necessary to solve the problem by themselves on the basis of the existing knowledge from the lecture. |
| **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** | Bioprocess Engineering: Specialisation A - General Bioprocess Engineering: Elective Compulsory<br>Energy and Environmental Engineering: Core Qualification: Compulsory<br>International Management and Engineering: Specialisation II. Energy and Environmental Engineering: Elective Compulsory<br>International Management and Engineering: Specialisation II. Process Engineering and Biotechnology: Elective Compulsory<br>Process Engineering: Core Qualification: Compulsory |

| Course L0106: Applications of Fluid Mechanics in Process Engineering | |
|---|---|
| **Typ** | Recitation Section (large) |
| **Hrs/wk** | 2 |
| **CP** | 2 |
| **Workload in Hours** | Independent Study Time 32, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Schlüter |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | The Exercise-Lecture will bridge the gap between the theoretical content from the lecture and practical calculations. For this aim a special exercise is calculated at the blackboard that shows how the theoretical knowledge from the lecture can be used to solve real problems in Process Engineering. |
| **Literature** | 1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.<br>2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.<br>3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.<br>4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.<br>5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.<br>6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006.<br>7. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008.<br>8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007<br>9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009.<br>10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.<br>11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008.<br>12. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.<br>13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882.<br>14. White, F.: Fluid Mechanics, Mcgraw-Hill, ISBN-10: 0071311211, ISBN-13: 978-0071311212, 2011. |

| Course L0001: Fluid Mechanics II | |
|---|---|
| **Typ** | Lecture |
| **Hrs/wk** | 2 |
| **CP** | 4 |
| **Workload in Hours** | Independent Study Time 92, Study Time in Lecture 28 |
| **Lecturer** | Prof. Michael Schlüter |
| **Language** | DE |
| **Cycle** | WiSe |
| **Content** | • Differential equations for momentum-, heat and mass transfer<br>• Examples for simplifications of the Navier-Stokes Equations<br>• Unsteady momentum transfer<br>• Free shear layer, turbulence and free jets<br>• Flow around particles - Solids Process Engineering<br>• Coupling of momentum and heat transfer - Thermal Process Engineering<br>• Rheology – Bioprocess Engineering<br>• Coupling of momentum- and mass transfer – Reactive mixing, Chemical Process Engineering<br>• Flow threw porous structures - heterogeneous catalysis<br>• Pumps and turbines - Energy- and Environmental Process Engineering<br>• Wind- and Wave-Turbines - Renewable Energy<br>• Introduction into Computational Fluid Dynamics |
| **Literature** | 1. Brauer, H.: Grundlagen der Einphasen- und Mehrphasenströmungen. Verlag Sauerländer, Aarau, Frankfurt (M), 1971.<br>2. Brauer, H.; Mewes, D.: Stoffaustausch einschließlich chemischer Reaktion. Frankfurt: Sauerländer 1972.<br>3. Crowe, C. T.: Engineering fluid mechanics. Wiley, New York, 2009.<br>4. Durst, F.: Strömungsmechanik: Einführung in die Theorie der Strömungen von Fluiden. Springer-Verlag, Berlin, Heidelberg, 2006.<br>5. Fox, R.W.; et al.: Introduction to Fluid Mechanics. J. Wiley & Sons, 1994.<br>6. Herwig, H.: Strömungsmechanik: Eine Einführung in die Physik und die mathematische Modellierung von Strömungen. Springer Verlag, Berlin, Heidelberg, New York, 2006.<br>7. Herwig, H.: Strömungsmechanik: Einführung in die Physik von technischen Strömungen: Vieweg+Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden, 2008.<br>8. Kuhlmann, H.C.: Strömungsmechanik. München, Pearson Studium, 2007<br>9. Oertl, H.: Strömungsmechanik: Grundlagen, Grundgleichungen, Lösungsmethoden, Softwarebeispiele. Vieweg+ Teubner / GWV Fachverlage GmbH, Wiesbaden, 2009.<br>10. Schade, H.; Kunz, E.: Strömungslehre. Verlag de Gruyter, Berlin, New York, 2007.<br>11. Truckenbrodt, E.: Fluidmechanik 1: Grundlagen und elementare Strömungsvorgänge dichtebeständiger Fluide. Springer-Verlag, Berlin, Heidelberg, 2008.<br>12. Schlichting, H. : Grenzschicht-Theorie. Springer-Verlag, Berlin, 2006.<br>13. van Dyke, M.: An Album of Fluid Motion. The Parabolic Press, Stanford California, 1882. |

# 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><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><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><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><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 |