Technische Universität München

Module Catalog

M.Sc. Management and Technology

TUM School of Management

Technische Universität München

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Technische Universität München

Module Catalog: General Information and Notes to the Reader

What is the module catalog?

One of the central components of the Bologna Process consists in the modularization of university curricula, that is, the transition of universities away from earlier seminar/lecture systems to a modular system in which thematically-related courses are bundled together into blocks, or modules.
This module catalog contains descriptions of all modules offered in the course of study.
Serving the goal of transparency in higher education, it provides students, potential students and other internal and external parties with information on the content of individual modules, the goals of academic qualification targeted in each module, as well as their qualitative and quantitative requirements.

Notes to the reader:

Updated Information

An updated module catalog reflecting the current status of module contents and requirements is published every semester. The date on which the module catalog was generated in TUMonline is printed in the footer.

Non-binding Information

Module descriptions serve to increase transparency and improve student orientation with respect to course offerings. They are not legally-binding. Individual modifications of described contents may occur in praxis. Legally-binding information on all questions concerning the study program and examinations can be found in the subject-specific academic and examination regulations (FPSO) of individual programs, as well as in the general academic and examination regulations of TUM (APSO).

Elective modules

Please note that generally not all elective modules offered within the study program are listed in the module catalog.

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Specialization in Management

One of the management specializations in the following seven tables must be selected.
In the chosen specialization, one seminar must be successfully completed from the seminars offered in the framework of the Advanced Seminar for at least 6 credits.
In addition, within chosen specialization, additional electives of a total of 24 credits must be earned from a supplementary elective catalog. The following is an example of such a catalog.

Technische Universität München

Specialization in Management: Innovation and Entrepreneurship

Advanced Seminar Innovation and Entrepreneurship

Module Description

WIB18812_1: Advanced Seminar Innovation & Entrepreneurship: Ideation & Venture Creation

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The grading is based on a research paper (10-15 pages, 75% of grade) and a presentation (15 min + 15 min interaction with the audience, 25% of grade). The research paper and the presentation will be conducted in groups formed in the introductory session. An assessment sheet filled in by the students and handed in with the research paper clarifies students' individual contribution to the research paper. As every student will present in the final presentation, every students' contribution is clearly identifiable and appraisable, thus, students can be graded individually. Based on the research paper it is examined to which extent students are able to elaborate complex topics in the field of entrepreneurship research. The research paper is a means to measure how students were able to understand previous academic literature in the field of entrepreneurship, how they achieved to define their own research question, collect and analyze data, and provide a relevant, novel, and interesting contribution to entrepreneurship research. A final presentation measures students' communicative competencies and proves if students are able to present their findings in a comprehensible, precise and demonstrative way as well as whether they are able to perform powerfully and professionally.

Repeat Examination:
Next semester / End of Semester

(Recommended) Prerequisites:
none

Content:
The module deals with different topics within entrepreneurship research such as
- discovering entrepreneurial role models,
- psychology of entrepreneurship,
- entrepreneurial leadership,
- ideation and venture creation,
- venture growth and
- internationalization and strategic entrepreneurship.

The module prepares students for the scientific work in their master theses and provides them with deepening insights into scientific literature on entrepreneurship. Besides writing a seminar paper, this involves presenting their final results.

Intended Learning Outcomes:
Upon successful completion of this module, students will be able (1) to read and (2) understand scientific literature on the topic of entrepreneurship. Furthermore, students are able (3) to create their own research paper, i. e., identifying a relevant, interesting, and new research topic in the field of entrepreneurship, crafting a strong title, writing a compelling and strong introduction (and abstract), execute an extensive literature review and applying theory, structure the research paper meaningful, writing a strong discussion and conclusion, and complying with the ethics of writing. Additionally, they will be able (4) to present their research paper and (5) summarize their findings. Moreover, students learn how (6) to lead a scientific discussion. Finally, they (7) understand the process of scientific publication. Moreover, working in groups will provide students with communication and cooperation skills.

Teaching and Learning Methods:
The module consists of an introduction to scientific writing where the topics for each student's research paper will be decided. Topics vary and cover entrepreneurship on an individual (e.g., entrepreneurial decision making, entrepreneurial intentions), team (e.g., entrepreneurial team formation, entrepreneurial exits), or organizational level (e.g., interplay of form, structure, and embeddedness in corporate entrepreneurship). Based on their topic students prepare their research paper which they will present at the end of the module. Upon prior discussion on different research methods and how to use them, the students will identify and apply a research methodology that best addresses their identified research question, i.e., they can apply empirical research methods (qualitative or quantitative), a literature review, or conduct a conceptual paper. Furthermore, the module involves (group and/or) individual feedback sessions, where students can share their progress and receive feedback. The students are supervised by the instructors of the module who are members the chair. Within the module the topics will be discussed after the final presentations.

Media:
MS Office, PowerPoint, Whiteboard, Flipchart

Reading List:
Hisrich, R. D./Peters, M. P./Shepherd, D. A.: Entrepreneurship, 8th edition, McGraw-Hill, 2010
Further readings will be announced at the course introduction.

Responsible for Module:
Patzelt, Holger; Prof. Dr. rer. pol.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Seminar Innovation & Entrepreneurship (WIB18812_1): Ideation & Venture Creation _ Group 2 (seminar, 4 SWS)
Patzelt H [L], Patzelt H, Rosenberger J

For further information in this module, please click
campus.tum.de or here.

Elective Modules Innovation and Entrepreneurship

Module Description

WI000116: Lead User Project [LUP]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	German	one semester	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The progress of the project is verified several times during the different project phases.
- Midterm presentation (voluntary): Students have to show that they developed critical knowledge and competencies with the industry of the project partner and that they identified trends and needs in the respective industry.
- Final presentation (30 minutes): Students propose different workshop combinations of lead users and assess constellations of expert panels based on their industry insights they developed over the course of the project.
- Project report (25 pages): Students document their key learnings along the entire project process as well as how the project contributes to their personal development into a successful career in management.
Students learn to present results in front of our cooperation partner. Furthermore, they document the results in a project report including the scientific theory of the lead user method.
Consistently, grading of the module is based on a project work (project report 25 pages and presentation 30 minutes). The progress of the project is verified several times during the different project phases.
Students have the possibility of a midterm presentation in which they have to show that they dealt with the industry of the project partner. They show their ability to identify and consider trends and needs in the respective industry. This midterm presentation is highly recommended because students can gain further knowledge for their final presentation. With this presentation the final grade can be improved by 0,3/0,4.
With the final presentation students show on the one hand the project progress and propose different workshop combinations of lead users. On the other hand they show their ability to conduct interviews with experts and to communicate and present on a high business level. They are able to judge the branch-specific challenges and identify experts who complete each other perfectly in workshops.
In the project report the students show their ability to document their project process and their findings in a clear and comprehensible manner. Furthermore they show their ability to analyze and evaluate the challenges in this industry.
With this project work students show that they can present results in front of our cooperation partner. Furthermore they show that they can compose a project report in which they formulate their practical results and combine them with the scientific theory of the lead user method.
The project work is conducted by teams of 4 students. Students demonstrate their ability within a team to manage resources, and deadlines through timely submission of the enumerated tasks. The project work is set up in a way which enables the identification and evaluation of each student's individual contribution to the project's success.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fundamentals of Technology and Innovation Management

Content:
The lead user project is a practical module. Participants in teams of 4 perform a lead user project in cooperation with an industry partner.
- We apply the lead user method developed by Eric von Hippel at MIT
- Starting point is the industry of our cooperation partner

The participants learn to understand the target industry:
- Search for trends and needs in the industry
- Identification of lead users

Students get to know the cooperation partner as well as its industry. The students are working independently and are coached regularly. In addition two professional presentation coachings are offered. Dr. Christian Hackl from TUMtech gives Feedback how to improve presentation content and style.

A successful participation encourages students to be creative, proactive, and work in teams.

Intended Learning Outcomes:
After successful completion of this module students will be able to describe the lead user method and understand its advantages. Students will know different methods to identify trends and needs. They will be able to deal intensively with a targeted industry and can evaluate the challenges in this industry. They will be able to identify experts and to develop a workshop for these experts. The students will be able to present their results in front of company representatives. Furthermore, they will be able to document their results in a clear and comprehensible manner.
Students can contribute an own part to a team's work output. Students are able to exchange in a professional and academic manner within a team. They show that they are able to integrate involved persons into the various tasks considering the group situation. Furthermore the students conduct solution processes through their constructive and conceptual acting in a team.

Teaching and Learning Methods:
During a real life innovation project students learn the theory of the lead user method and apply it during the module. The module is a practical project and the students get to know the different stages of a lead user project and work together with our industry partner. The students deal intensively with the target industry.
- During the kick-off the lead user method is explained
- The students work independently and are coached regularly during the project
- Students present their results after the first phase (need identification) and at the end of the project (lead user identified)
- Before the presentations a professional presentation coaching with Dr. Christian Hackl (TUMtech) will take place

Media:
Participants receive all presented slides and research papers about the lead user method.

Reading List:
- Glen L. Urban / Eric von Hippel (1988). Lead User Analyses for the Development of New Industrial Products, Management Science, Vol. 34, No. 5, pp. 569-582.
- Herstatt, C., Lüthje, C., & Lettl, C. (2003). Fortschrittliche Kunden zu Breakthrough-Innovationen stimulieren. In Management der frühen Innovationsphasen (pp. 57-71). Gabler Verlag.
- Henkel, J., Jung, S. (2009) The Technology-Push Lead User Concept: A New Tool for Application Identification, http://www.researchgate.net/publication/228820209_The_Technology-Push_Lead_User_Concept_A_New_Tool_for_Application_Identification/links/00b7d521ce2d489500000000
- Lüthje, C. (2000), Kundenorientierung im Innovationsprozess, S. 130-152.
- v. Hippel, E. / Thomke, S. / Sonnack, M. (1999), Creating Breakthroughs at 3M, Harvard Business Review, September-October, S. 47-57.
- v. Hippel, Eric. Democratizing innovation. MIT press, 2005.

Responsible for Module:
Henkel, Joachim; Prof. Dr. rer. pol.

Courses (Type of course, Weekly hours per semester), Instructor:
Lead-User Project (WI000116) (seminar, 4 SWS)
Henkel J, Obermeier D

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

WI001166: Advanced Topics in Innovation & Entrepreneurship: Entrepreneurial Prototyping

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Master	English	one semester	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The grading is based on a research paper (10-15 pages, 75% of grade) and a presentation (15 min + 15 min interaction with the audience, 25% of grade). The research paper and the presentation will be conducted in groups formed in the introductory session. An assessment sheet filled in by the students and handed in with the research paper clarifies students' individual contribution to the research paper. As every student will present in the final presentation, every students' contribution is clearly identifiable and appraisable, thus, students can be graded individually. Based on the research paper it is examined to which extent students are able to elaborate complex topics in the field of entrepreneurship research. The research paper is a means to measure how students were able to understand previous academic literature in the field of entrepreneurship, how they achieved to define their own research question, collect and analyze data, and provide a relevant, novel, and interesting contribution to entrepreneurship research. A final presentation measures students' communicative competencies proves if students are able to present their findings in a comprehensible, precise and demonstrative way as well as whether they are able to perform powerfully and professionally.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
none

Content:
The module deals with different topics within entrepreneurship research such as

- discovering entrepreneurial role models, this might include to explore
o links between role models and entrepreneurial intentions
o reasons for the choice of the entrepreneurial career
- psychology of entrepreneurship, this might include to explore
o personality dimensions of entrepreneurs
o entrepreneurial cognition
- entrepreneurial leadership, this might include to explore
o behavioral forms of leadership
o creating and managing innovative organizations
- ideation and venture creation, this might include to explore
o the process of obtaining creative ideas
o the process model of entrepreneurial venture creation
- venture growth, this might include to explore
o how new ventures grow and where growth occurs
o different impact factors on new venture growth

- internationalization and strategic entrepreneurship, this might include to explore
o the speed of entrepreneurial internationalization
o enabling forces of technology, competition, perceptions, knowledge and networks
The module provides students with deepening insights into entrepreneurship literature. Besides writing a seminar paper, this involves presenting their final results.

Intended Learning Outcomes:
Upon successful completion of this module, students will be able to read and understand related literature on the topic of entrepreneurship. Furthermore, students are able to create their own research paper. Additionally, they will be able to present their paper and summarize their findings. Moreover, students learn how to lead a discussion on their topic. Finally, they understand entrepreneurial processes.
At the end of the module, students will be able to:
- explain entrepreneurship concepts related to a specific topic.
- discuss current topics within the field of entrepreneurship.
- apply previously discussed approaches to topic specific issues within the field of entrepreneurship.
- evaluate these approaches and their outcomes.
- develop suitable approaches for specific entrepreneurship issues.

Teaching and Learning Methods:
The module consists of an introduction to scientific writing where the topics for each student's research paper will be decided. Topics vary and cover entrepreneurship on an individual (e.g., entrepreneurial decision making, entrepreneurial intentions), team (e.g., entrepreneurial team formation, entrepreneurial exits), or organizational level (e.g., interplay of form, structure, and embeddedness in corporate entrepreneurship). Based on their topic students prepare their research paper which they will present at the end of the module. Upon prior discussion on different research methods and how to use them, the students will identify and apply a research methodology that best addresses their identified research question, i.e., they can apply empirical research methods (qualitative or quantitative), a literature review, or conduct a conceptual paper. Furthermore, the module involves (group and/or) individual feedback sessions, where students can share their progress and receive feedback. The students are supervised by the instructors of the module who are members the chair. Within the module the topics will be discussed after the final presentations.

Media:
MS Office, PowerPoint, Whiteboard, Flipchart

Reading List:
Hisrich, R. D. / Peters, M. P. / Shepherd, D. A.: Entrepreneurship, 8th edition, McGraw-Hill, 2010 (optional)
Obligatory readings will be announced at the course introduction.

Responsible for Module:
Breugst, Nicola; Prof. Dr. rer. pol.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Topics in Innovation & Entrepreneurship (WI001166): Entrepreneurial Prototyping (seminar, 4 SWS)
Breugst N [L], Leibinger H, Reetz D

For further information in this module, please click
campus.tum.de or here.

Specialization in Management: Marketing, Strategy and Leadership

Advanced Seminar Marketing, Strategy and Leadership

Module Description

WIB17003: Advanced Seminar Marketing, Strategy & Leadership: Judgement and Strategic Decision Making

Judgement and Strategic Decision Making

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Master	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:

The examination comprises a research paper (seminar paper (10 pages excl. literature & attachments) with presentation (30 minutes incl. discussion)), which demonstrates that students
- are able to understand and interpret the scientific literature on a specific topic in the field of strategic decision-making, and are able to draw upon scientific literature in a results-oriented and structured manner.
- are able to apply scientific methods to provide answers to questions in the field of strategy and organization that are relevant to business practice.
- possess presentation and communication skills that enable them to present, in a clear and structured manner, their findings on scientific challenging topics they have worked on independently, and to discuss the applicability of their findings to business practice.

The final grade is an averaged grade from the seminar paper (75%) and the presentation (25%).

Repeat Examination:

Next semester

(Recommended) Prerequisites:

None

Content:

How are decisions actually made in theory and practice?

This module enriches students' knowledge of judgment and strategic decision making (JSDM) on a theoretical and a practical level. JSDM has been regarded as the core of an organization's operation and a core competence of any top-level executive. In this course, we will introduce different perspectives on JSDM. More specifically, we will discuss three different perspectives, First, what are the drivers of individual, group and organizational decisions from a psychological perspective including common biases and errors present in strategic decision? Second, how can decisions nowadays be based on data science approaches including AIs and machine learning algorithms? Third, how are decisions actually made in practice and what are key questions managers face when making strategic decisions?

Intended Learning Outcomes:

Theory:

Students know and understand the most important theories about behavioral decision making from various perspectives in how to make better strategic decisions and be able to apply a framework for how society and management could improve their decision making.

Practice:

Students understand how decision making occurs from a practitioner's point of view and will be able to integrate these viewpoints with scientific theory.

Method:
Students will gain insights into research methods in the applied setting of decision making, data-driven decisions and strategic management research.
They are able to analyze different streams of theory, conduct efficient decision making studies and apply results in practice.
They are able to research, analyze, and evaluate scientific literature.

Teaching and Learning Methods:
Over the course of the semester, students work on a scientific and application-orientated topic. They work both on their own (in particular while working on their seminar paper) and in small groups together with other seminar participants. The lecturers give presentations on the most important theories as well as current research findings on a specific topic in the field of strategy, organization, and leadership (depending on the concrete subject of the seminar). By reading scientific literature (self-study), students deepen their knowledge of theories and methods in the field and get used to working with scientific literature. Guest lectures by regularly changing speakers from the business sector (often high-level decision-makers) as well as case study work enable students to establish a connection between questions from business practice and scientific theories and research findings.

Media:
Slides, case studies, scientific literature

Reading List:
Bazerman, M. H. & Moore, D. (2013). Judgment in Managerial Decision Making (8th ed.). Hoboken, NJ: John Wiley & Sons.
Gigerenzer, G. & Gaissmaier, W. (2011). Heuristic decision making. Annual Review of Psychology, 62, 451-482.
Tversky, A. & Kahnemann, D. (1974). Judgment under uncertainty: Heuristics and biases. Science, 185, 1124-1131.
Weber, E. U. & Johnson, E. J. (2009). Mindful judgment and decision making. Annual Review of Psychology, 60, 53-85.

Responsible for Module:
Welpe, Isabell M.; Prof. Dr. rer. pol.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Seminar Marketing, Strategy & Leadership (WIB17003): Judgment and Strategic Decision Making (seminar, 4 SWS)
Folger N, Höllig C, Rüll H

For further information in this module, please click
campus.tum.de or here.

Elective Modules Marketing, Strategy and Leadership

Module Description

WI001140: Luxury Marketing

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Master	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The final grade is based on group presentations. During the module two presentations have to be held. One short presentation (25% of grade, presenting an article - 20 min) aims to prove if students are able to connect the theoretical material on luxury marketing with empirical results of the contemporary research, if they are able to analyze and present an academic article in a clear and organized way, and if their able to provide a personal interpretation of the article. The second presentation (75% of grade, 45 min) assesses if the students understand the main elements of a luxury strategy with a focus on the 4Ps, and if they are able to apply the theoretical learning to a real case by conducting an audit of a luxury brand and by giving recommendations of how to improve the luxury marketing strategy of the assigned brand. They can use the theoretical material (lecturer´s slides) as a support and they have to collect secondary data. This presentation is combined with a written composition that illustrates the results of the audit. The presentations are done by groups of four students. The students will receive an individual grade: the individual contribution will be identified by evaluating a personal recommendation to the luxury brand that each students has to provide as a result of the audit, and by evaluating the individual communication skills. Both presentations are followed by a discussion in which all the students can voluntarily participate.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:

Content:
* First, the module starts with a discussion about how the meaning of luxury evolved from the past until now. It will elaborate how luxury differs from other related concepts.
* Second, it will focus on understanding consumer behavior association with luxury products and brands. In particular, it will identify the underlying drivers of conspicuous consumption (e.g. self-reward, social elevation) and what consumers want to signal through the purchase of luxury products (e.g. status, wealth, power).
* Third, the module will discuss best practices, do's and don'ts, when it comes to building, managing, and extending luxury brands. Especially, the symbolic power and the identity of luxury brands will be discussed.
* Last but not least, it will discuss the 4Ps of luxury marketing and how to leverage them to develop an effective marketing strategy.

Intended Learning Outcomes:
Upon successful completion of this module, students are able (1) to understand the basic elements and the specific challenges of marketing luxury products and (2) to give examples from empirical evidence of the theoretical concepts. They are also able (3) to analyze, (4) review and (5) present academic papers related to the topic of luxury of the contemporary research. Finally, they are able (6) to conduct an audit of a luxury brand (7) by making

recommendations to improve the luxury marketing strategy of the assigned brand and (8) to improve their communication skills.

Teaching and Learning Methods:
The module uses various teaching methods that should help facilitate students' learning. The students are provided during the lectures with theoretical material to acquire the basic knowledge of luxury marketing. The students have to present academic papers in class and discuss them with peers, in order to explore empirical results related to theoretical concepts. They also have to prepare an audit of a luxury brand focused on the 4Ps (product, price, promotion, and place), which they have to present in class, in order to apply in practice the theoretical learning. The audit can be performed using the theoretical material presented in class as a support.

Media:

Reading List:
- Han, Y. J., Nunes, J. C., & Drèze, X. (2010). Signaling status with luxury goods: The role of brand prominence. Journal of Marketing, 74(4), 15-30.
- Wang, Y., & Griskevicius, V. (2014). Conspicuous consumption, relationships, and rivals: Women's luxury products as signals to other women. Journal of Consumer Research, 40(5), 834-854.
- Bellezza, S., Gino, F., & Keinan, A. (2014). The red sneakers effect: Inferring status and competence from signals of nonconformity. Journal of Consumer Research, 41(1), 35-54.
- Mandel, N., Petrova, P. K., & Cialdini, R. B. (2006). Images of success and the preference for luxury brands. Journal of Consumer Psychology, 16(1), 57-69.
- Rucker, D. D., & Galinsky, A. D. (2008). Desire to acquire: Powerlessness and compensatory consumption. Journal of Consumer Research, 35(2), 257-267.
- Griskevicius, V., Tybur, J. M., & Van den Bergh, B. (2010). Going green to be seen: status, reputation, and conspicuous conservation. Journal of personality and social psychology, 98(3), 392.
- Hagtvedt, H., & Patrick, V. M. (2008). Art and the brand: The role of visual art in enhancing brand extendibility. Journal of Consumer Psychology, 18.
- Hagtvedt, H., & Patrick, V. M. (2009). The broad embrace of luxury: Hedonic potential as a driver of brand extendibility. Journal of Consumer Psychology, 19.
- Fuchs, C., Prandelli, E., Schreier, M., & Dahl, D. W. (2013). All that is users might not be gold: How labeling products as user designed backfires in the context of luxury fashion brands. Journal of Marketing, 77(5), 75-91.
- Wilcox, K., Kim, H. M., & Sen, S. (2009). Why do consumers buy counterfeit luxury brands?. Journal of Marketing Research, 46(2), 247-259.
- Willems, K., Janssens, W., Swinnen, G., Brengman, M., Streukens, S., & Vancauteren, M. (2012). From Armani to Zara: Impression formation based on fashion store patronage. Journal of Business Research, 65(10), 1487-1494.
- Ward, M. K., & Dahl, D. W. (2014). Should the Devil Sell Prada? Retail Rejection Increases Aspiring Consumers' Desire for the Brand. Journal of Consumer Research, 41(3), 590-609.

Responsible for Module:
Fuchs, Christoph; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Luxury Marketing (WI001140) (lecture, 4 SWS)
Fuchs C [L], Caprioli S

For further information in this module, please click
campus.tum.de or here.

Specialization in Management: Operations and Supply Chain Management

Advanced Seminar Operations and Supply Chain Management

Module Description

WIB19837: Advanced Seminar Operations & Supply Chain Management: Production and Supply Chain Management

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Master	English	one semester	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The students write a research paper (max. 25 pages) relating to a specific topic within the focus of the module, in which they demonstrate that they can perform a small research project from a discussion of the relevant literature, analysis of problem and solution approaches to the application in examples or cases and the identification of directions for future research. A final presentation (30 minutes with ensuing Q&A) proves that students are able to present their work to a scientific audience in a precise, comprehensible and demonstrative way. Further information will be announced at the beginning of the semester.
Research paper and presentation will be graded as one contribution/examination, individual weighting is not applicable

Repeat Examination:
Next semester

(Recommended) Prerequisites:
It is expected that participants have an interest in practical problems of production planning, scheduling and logistics, and the quantitative modelling of business problems. Participants should be familiar with Operations Research (OR) techniques.

The modules "Management Science" and "Production and Logistics" or similar modules at other universitites are a prerequisite.

It is strongly advised that the participants have previously taken part in the module "Modelling, Optimization and Simulation in Operations Management" or similar modules at other universities.

Content:
The development of methods and tools for quantitative operations and supply chain management can be challenging. Different contextual factors often require the adaptation of tools and methods. In this module, a specific focus within operations and supply chain management will be studied, and its specific challenges in terms of developing quantitative decision support tools will be addressed.
After a general analysis of the focus area and its main challenges, we identify several specific operations and supply chain management requirements with regard to supporting decision-making in practice. Using different scientific papers, we investigate possibilities to deal with the specific challenges, and see how traditional production planning and control methods and concepts can be utilized in this context.

Intended Learning Outcomes:
At the end of the module the students will be able to:
- Review state-of-the-art in operations and supply chain management approaches related to the module focus.
- Apply literature findings and/or methodologies to examples or case studies.

- Critically evaluate the scientific contributions of the analyzed literature.
- Analyze problems and solution approaches for operations and supply chain management methods and tools in the context of the module focus.
- Develop ideas for future research in relation to the module focus.
- Adequately communicate and discuss scientific contributions and research findings within the focus of the module

Teaching and Learning Methods:
The module consists of a seminar. The contents is delivered through presentations by the students. The students improve the acquired knowledge by studying the suggested literature. The students will be supervised by the lecturer when they work on their topic.

Media:
Presentation slides
Technical papers

Reading List:
van Weele, Arjan J., Purchasing and Supply Chain Management, 2014

Research papers

Responsible for Module:
Grunow, Martin; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Seminar Operations & Supply Chain Management (WIB19837): (Process Industry) (seminar, 4 SWS)
Grunow M [L], Forel A, Grunow M, Pahr A, Schömig-Beißner M

For further information in this module, please click
campus.tum.de or here.

Elective Modules Operations and Supply Chain Management

Module Description

WIB19823: Advanced Topics in Operations & Supply Chain Management I

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	irregularly
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The assessment takes place in form of a written exam (120 min) at the end of the semester. In the exam students demonstrate that they are able to explain, discuss and critically evaluate specific concepts of quality management. Furthermore, they proof that they can apply the discussed quantitative approaches for operations and supply chain management, critically evaluate them and discuss the results. The answers involve own formulations, as well as calculations or mathematical modelling.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge of quantitative approaches to production and supply chain management. The modules "Management Science" and "Production and Logistics" or similar modules at other universitites are a prerequisite.

Content:
In this module, we address current topics in production and supply chain management on a graduate -level. This module covers the statistical basis for the design of experiments, product and process control (SPC) and reliability engineering. Quality assurance is examined, from the viewpoint of quality incorporated into product design, maintaining quality in production and procurement risk, using both quantitative problems and case studies and a hands-on Failure Mode and Effects Analysis exercise. Quality systems are introduced using an interactive Six-Sigma scenario. Quality management and the concept of using quality as a driver for change in an organization will help demonstrate the complexity of change management in an organization.

Intended Learning Outcomes:
By the end of this module, students will be able to:
- Review the key milestones in the integration of quality in products and business processes and understand the essential drivers and costs behind successful quality management.
- Estimate population quality from sample quality and make inferences about population parameters using confidence intervals, hypothesis testing, and goodness-of-fit tests.
- Explain the role of reliability in product design.
- Design process and product experiments and assess the effect of possible process failures on the product quality using the Failure Modes and Effects Analysis.
- Determine appropriate control limits in order to measure the capability of a process and understand how control charts are used in industry to monitor and improve quality.
- Perform process and equipment correlation to identify the root cause(s) of a process deviation.
- Compare methods managing supply risk and recommend solutions.
- Discuss the issues involved in managing for quality at different operational levels.
- Apply 6-Sigma principles to quality projects.

- Understand the 8-Disciplines methodology for problem analysis and problem solving.
- Analyse industry cases, applying the principles from the class, draw conclusions and present the results.

Teaching and Learning Methods:
The module consists of a lecture. Presentations by the lecturer are used to introduce the concepts and approaches. Case studies and in-class exercises are used to enable the students to work together and apply the concepts and quantitative approaches introduced in the course. They are encouraged to present and discuss their findings. Furthermore, students are encouraged to study the suggested literature.

Media:
Presentation slides
Technical papers, Case studies

Reading List:
A First Course in Quality Engineering: Integrating Statistical and Management Methods of Quality, K.S. Krishnamoorthi, CRC Press, 2012.

Responsible for Module:
Grunow, Martin; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Topics in Operations & Supply Chain Management I (WIB19823): (Quality Management) (lecture, 4 SWS)
Fedrow E, Ott H

For further information in this module, please click
campus.tum.de or here.

Specialization in Management: Finance and Accounting

Advanced Seminar Finance and Accounting

Module Description

WIB23005: Advanced Seminar Finance & Accounting: Behavioral and Experimental Economics

Behavioral & Experimental Economics
TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Master	German	one semester	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The final grading is based on a research paper (70%) including a presentation (30%). The research paper (11-13 pages) is a written draft of a topic. The research paper will be written in teams, whereas single parts have to be assigned to single team members. By writing the research paper in teams, students demonstrate their ability within a team to manage resources, and deadlines through timely submission of the enumerated tasks. Students demonstrate that they are able to complete the tasks of their project in a team environment.
The research paper reveals the student's acquired abilities in identifying a reasonable and relevant research question in behavioral economics. Moreover, the research paper reveals the student's ability to develop research designs and analytical methods to examine the identified research question. Students show that they are able to interpret and to communicate the results.
Furthermore students are asked to present (20 minutes + 10 minutes discussion) their research paper in front of the class. By presenting their findings in front of the class, students proof that they are able to present the key aspects in a concise manner and that they are able to answer further questions on their presented findings.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Working knowledge of the mandatory basic business courses

Content:
The module offers participants an overview of current issues in behavioral economics and gives them the opportunity to examine one topic in more detail. The module may serve as starting point for further research, but also prepares participants for issues they are likely to face in their professional lives. Emphasis is put on aspects of experimental economics, social preferences, nudging, herding, and further phenomena of behavioral economics.

Intended Learning Outcomes:
After completing this module, students have an advanced knowledge of the module's core topic. They are able to identify theoretical and practical research questions and to develop research designs and analytical methods to examine the identified research question. In this context, they will compile a literature research and structure their work. Moreover, they are able to interpret and communicate the identified outcomes in an academically suitable way. Besides, the participants will be enabled to objectively analyze other seminar papers. They recognize potential conflicts in working together as a team and they reflect upon these considering varying conditions. They are able to integrate involved persons into the various tasks considering the group situation. Students are able to prepare a certain topic within a given time frame and to present it in clear and comprehensible manner to an

audience. They can react and respond to questions and suggestions relating to their subject area brought up by the audience during a discussion.

Teaching and Learning Methods:
This module is a seminar. Students will read, discuss and work with academic research papers. In the course of the module students will write a research paper and present their findings in class. In interactive discussions students react to questions and comments of their classmates. In this interactive seminar atmosphere students get a detailed insight to topics of behavioral economics.

Media:
Books, case descriptions, academic papers, presentation slides

Reading List:
Gneezy, U., & Rustichini, A. (2000). Pay enough or don't pay at all. The Quarterly Journal of Economics, 115(3), 791-810.

Frey, B. S., & Oberholzer-Gee, F. (1997). The cost of price incentives: An empirical analysis of motivation crowding-out. The American economic review, 87(4), 746-755.

Gneezy, U., & Rustichini, A. (2000). A fine is a price. The Journal of Legal Studies, 29(1), 1-17.

Ariely, D., Bracha, A., & Meier, S. (2009). Doing good or doing well? Image motivation and monetary incentives in behaving prosocially. American Economic Review, 99(1), 544-55.

Falk, A., & Fischbacher, U. (2006). A theory of reciprocity. Games and economic behavior, 54(2), 293-315.

Camerer, C., Babcock, L., Loewenstein, G., & Thaler, R. (1997). Labor supply of New York City cabdrivers: One day at a time. The Quarterly Journal of Economics, 112(2), 407-441.

Responsible for Module:
Mohnen, Alwine; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Seminar in Finance and Accounting (WIB23957): Behavioral and experimental economics. An introduction. (seminar, 4 SWS)
Mückenhausen V, Sittenthaler H

For further information in this module, please click
campus.tum.de or here.

Elective Modules Finance and Accounting

Specialization in Management: Economics and Policy

Advanced Seminar in Economics and Policy

Technische Universität München

Module Description

WIV05001: Advanced Seminar Economics & Policy: Economics of Innovation

Economics of Innovation
TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Master	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The students will work in small groups on one of five topics: Creation of knowledge, diffusion of knowledge, industry and macroeconomic aspects, intellectual property rights, innovation policy. The group work aims at 1) understanding the topic in depth and 2) presenting the most important insights from their topic to classmates. Moreover, the students will derive research gaps in the literature related to their topic and summarize both main insights and research gaps in a presentation (20-30 min. per person) to the class. By presenting in a team, students demonstrate their ability within a team to manage resources, and deadlines through timely submission of the enumerated tasks. Finally, they will submit an extended version of the presentation topic as a written research paper (8.000 to 10.000 words). By writing the research paper, students show their ability to work independently on solving complex scholarly problems related to the Economics of Innovation.
The final grade will be based on the written research paper with a weight of 80% and the presentation with a weight of 20%

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Familiarity with microeconomics

Content:
This module will provide students in-depth insights into the field of the Economics of Innovation. The module will discuss some of the prevailing models in the field of Industrial Organization dedicated to the analysis of the incentives and constraints to innovative activities (R&D activities) as well their relation with imitation, spillovers, firm size and market structure. The module also comprises a dynamic and knowledge-based view, introducing models involving the direct generation of new knowledge, the catching-up/falling behind dynamics of competition and the role played by market selection between innovative firms. The objective of is also to apply the acquired knowledge to selected topics in the field of innovation research. The students will be asked to write a research paper and to present their work in class.

Intended Learning Outcomes:
This module introduces the students to the main issues in the economics of innovation and advances their understanding of the core concepts and principles in the field. The ultimate objective to enhance both theoretical as well as an applied view on the topic enabling students to understand academic as well as public debate on questions related to the economics behind innovation and technological progress. Upon successful completion of this module, students will be therefore able (1) to identify and (2) conceptualize different important issues related to the Economics of Innovation. They (3) are able to identify gaps in the understanding of the focal topic and (4) developed suggestions for improving the understanding of the field. In addition, by presenting their topic to the

class, they will (5) enhance their presentation skills and by writing the research paper (6) their scientific writing skills. Through working in groups, the (6) students will work on their teamwork skills.

Teaching and Learning Methods:
The module is a seminar, in which the students will gain in-depth insights in the Economics of Innovation. The seminar will start with an introductory lecture, which will provide the bases for deeper study of the most relevant topics. The first phase will then concentrate on problem-based learning by reading relevant scientific literature and by discussing these articles in the group. In the second phase, students will individually elaborate a written paper as well as presentations in which they need to show their understanding of their focal topic as well as show their capability to identify research gaps in the discussed literature.

Media:

Reading List:
in general:
- Fagerberg, J., Mowery, D. and Nelson, R. R. (2010), Oxford Handbook of Innovation, Oxford: Oxford University Press
- Hall, B. H. and Rosenberg, N. (2010), Handbook of the Economics of Innovation, Oxford: Elsevier,
specific topics:
- Czarnitzki, D., Hottenrott, H. and Thorwarth, S. (2011) `Industrial research versus development investment - the implications of financial constraints', Cambridge Journal of Economics, 35, 527-544.

- Jaffe, A., Trajtenberg, M. and Henderson, R. (1993), `Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations', Quarterly Journal of Economics, 108, 577-598.
- Aghion, P., Dechezleprêtre, A., Hemous, D., Martin, R. and Van Reenen, J. (2016), `Carbon Taxes, Path Dependency and Directed Technical Change: Evidence from the Auto Industry', Journal of Political Economy, 124 (1).
- Gallini, N. und Scotchmer, S. (2002), `Intellectual Property: When Is It the Best Incentive System?', in: Jaffe et al. (Eds.), Innovation Policy and the Economy, MIT Press, 51-77.
- Lundval & Borrás (2005), `Science, technology, and innovation policy', in: Fagerberg, J., Mowery, D. and Nelson, R. R. (eds.), Oxford Handbook of Innovation, Oxford: Oxford University Press, 599-631.

Responsible for Module:
Hottenrott, Hanna; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Seminar in Economics & Policy (WIV05001): Economics of Innovation (seminar, 4 SWS)
Becker A, Römer K

For further information in this module, please click
campus.tum.de or here.

Elective Modules Modules Economics and Policy

Module Description

WI001145: Energy Economics

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module entails a final written exam (120 minutes). The exam is a closed-book exam. By answering the questions students show their ability to differentiate and evaluate different market structures (at wholesale, transportation and retail level) in energy markets, e.g. in gas, coal, oil and power markets. Moreover students show their ability to discuss and apply theoretical and empirical methods to selected topics in energy markets. They show that they are able to analyze and assess recent energy market developments, such as for instance the energy transition, using the theoretical and empirical tools they have acquired.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Courses at TUM or elsewhere in microeconomics and introductory statistics or econometrics

Content:
This module covers the following topics:
Economics of energy markets
Analysis of producer strategies
Analysis of consumer behavior
Fundamentals of primary energy markets
Fundamentals of electricity markets
Analysis of network industries
Network regulation
Microeconomics
Game theory
Econometrics
Energy policy

Intended Learning Outcomes:
Students are able to explain and to differentiate different market structures (at wholesale, transportation and retail level) in energy markets, e.g. in gas, coal, oil and power markets. Furthermore, they are able to summarize and compare different strategies and behavior of producers and consumers, as well as on different forms of regulation of network industries. Students are also able to discuss and apply theoretical and empirical methods to selected topics in energy markets. With these tools student will thus be able to analyze and assess recent energy market developments, such as for instance the energy transition.

Teaching and Learning Methods:
The module is a lecture consisting of PowerPoint presentations so as to offer and explain to students all different topics covered in this module. A guest lecture is planned in which practitioners present on selected topics in energy markets. The exercise course comprises different problem sets that discuss problems covered during the lecture. Problem sets are solved individually or in group work and, supported by a presentation, derived and solved jointly with the tutor.

Media:
PowerPoint, exercise sheets, whiteboard, reader

Reading List:
Viscusi, W. et al. (2005): Economics of Regulation and Antitrust, MIT Press. Stoft, S. (2002): Power System Economics, Wiley. Selected journal articles.

Responsible for Module:
Schwenen, Sebastian; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Energy Economics (WI001145) (lecture, 2 SWS)
Schwenen S

Energy Economics - Exercise (WI001145) (exercise, 2 SWS)
Schwenen S, Bohland M

For further information in this module, please click
campus.tum.de or here.

Specialization in Management: Energy Markets

Advanced Seminar Modules Energy Markets

Module Description

WIB29001: Advanced Seminar Energy Markets

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module assessment consists of a research paper (80% of the grade) and a presentation (20% of the grade). Students have to author a research paper (approx. 25 pages) and to give a talk (approx. 60 minutes). By writing the research paper students show that they are able to reproduce the main insights and analyze complex issues in energy market relevant topics. Students demonstrate that they are able to conduct an individual research work and write a research paper using scientific methods. They are show that they are able to discuss and evaluate the advantages and drawbacks of new developments in in the area of energy markets.
By presenting their topic to the audience students demonstrate their communication competency in presenting scholarly work in a structured and systematic way to an audience. Furthermore students show that they are able to respond competently to any questions, suggestions or discussions brought by the audience and relate it to their subject area.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in energy markets

Content:
Key topics of the module may include:
- Current issues in energy market design
- Current issues in energy finance
- Applications of Operations Research to problems arising in the energy industry

Intended Learning Outcomes:
Upon successful completion of this module students will be able to reproduce the main insights and analyze complex issues in energy market relevant topics. Students will be able to conduct an individual research work and write a research paper on their own. Students will be able to discuss and evaluate the advantages and drawbacks of new developments in in the area of energy markets. Moreover students will be able to summarize specific issues and results to their essential core. They are able to prepare a certain topic within a given time frame and to present it in clear and comprehensible manner to an audience. They are able to respond competently to any questions, suggestions or discussions brought by the audience and relate it to their subject area

Teaching and Learning Methods:
The module is a seminar, in which the students will be assigned state-of-the-art research papers from the recent

literature. They are expected to prepare high-quality presentations and write-ups, reflecting their analyses, understanding and insights from reading the papers and related literature. The lecturer will provide guidance and advice all along, from the choice of the initial topic, to tips on reading original literature, on scientific writing, and on giving successful presentations

Media:
Power-Point slides

Reading List:
Bhattacharyya, S.: Energy Economics - Concepts, Issues, Markets and Governance. Springer 2011.

Responsible for Module:
Wozabal, David; Prof. Dr. rer. soc.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click
campus.tum.de or here.

Elective Modules Modules Energy Markets

Module Description

WI000946: Energy Markets I

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module entails a written exam at the end of the term (60 minutes). In order to optimally assess the students' achievements, the exam will consist of both, a multiple choice part (20%) and open questions (80%). In the multiple choice part students mainly show that they have professional knowledge regarding the characteristics of energy markets and that are able to classify it. With answering the open questions, students demonstrate their ability to solve problems as well as their ability of abstraction. Mathematical problems will be complemented by questions mainly aiming at economic intuition and thought patterns. Apart from a nun-programmable calculator no further tools or documents are permitted (closed book).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in economics (competition theory), basics in corporate strategy (Porter etc.), ideally industrial economics (market power, oligopoly, barriers to market entry, transparency etc.) and trade (call, put, forward, future etc.)

Modules:
- Investment and Financial Management
- Mikroökonomik (Economics I)
- Industrieökonomik (Industrial Economics)
- Introduction to Strategy and Organization

Content:
This module gives a broad overview of energy markets and energy industries across all commodities. It covers the whole energy value chain from primary energy supply to energy consumption and presents the most relevant economic concepts.
Focus issues are forecasting energy demand, primary energy exploration and production, supply and demand curves / merit orders in different commodities, specific feature of energy markets, price formation and organised energy trading.
The module will be continued in summer with energy markets 2, focusing on renewables and grid regulation.

Intended Learning Outcomes:
After successful participation in the module, students possess a broad basic knowledge regarding the economic specifications of energy markets. Furthermore, students are able to solve energy related problems self-reliantly

using both, mathematical techniques as well as attained economic intuition.
Participants are moreover able to transfer economic principles on the special demands of energy markets.
After studying the provided literature, students are able to analyze and assess questions arising in terms of energy policy and recent developments in the fields of energy markets.
Participation in the module leads to a better understanding of energy markets and enables students to develop and evaluate business processes and models in the field of energy economics.
Taking part in the module enables students to competently advocate their views in discussions addressing energy economics and markets.

Teaching and Learning Methods:
The module consists of a lecture and an associated exercise course. The lecture provides basic knowledge about economical characteristics of energy markets via presentations. Students are encouraged to study the literature and discuss the provided topics. During the exercise courses, selected examples of problems arising in energy markets are discussed.

Media:
Slides and exercises

Reading List:
Erdmann, G. / Zweifel, P. (2010) Energy Economics: Theory and Applications; Springer 2017.
Ströbele, W. / Pfaffenberger, W. / Heuterkes, M. (2012) Energiewirtschaft - Einführung in Theorie und Politik; 3. Auflage; Oldenbourg 2012.
Bhattacharyya, S. (2011) Energy Economics - Concepts, Issues, Markets and Governance; Springer 2011.

Responsible for Module:
Wozabal, David; Prof. Dr. rer. soc.

Courses (Type of course, Weekly hours per semester), Instructor:
Energy Markets I (WI000946) (lecture, 2 SWS)
Bieberbach F, de Almeida Terca G

Energy Markets I - Exercise (WI000946) (exercise, 2 SWS)
Bohland M, de Almeida Terca G

For further information in this module, please click
campus.tum.de or here.

Specialization in Management: Life Sciences and Management

Advanced Seminar Life Sciences and Management

Technische Universität München

Module Description

WIB14002: Advanced Seminar Life Sciences & Management: Sustainable Entrepreneurship - Theoretical Foundations

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The grading is based on a research paper (max. 7.500 words). The students show that they are able to apply theoretical perspectives to the context of life sciences. Moreover, they develop an argument matching the concept of sustainable entrepreneurship as a promising approach for addressing complex sustainability issues in general and in the field of life sciences in particular. In the research paper students show that they can evaluate different approaches and develop their own ideas for life sciecne-related sustainable ventures.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Courses in entrepreneurship, corporate sustainability and/or sustainability marketing are recommended.

Content:
Whether it is tackling climate change, resource degradation or social inequalities - responding to sustainability issues constitutes the biggest challenge for businesses in the 21st century. Embracing a great range of industries including food, energy or textiles, the field of life sciences is a key area for sustainability. Since the production of these goods accounts for an extensive use of resources, there is great potential for effecting real improvements on a way towards more sustainable production and lifestyles. The course "Advanced Seminar Life Sciences and Management" will investigate this exciting and ongoing industrial transformation. It will deal with the following topics (all topics will be explained in general and then discussed in the context of life sciences in particular):

1) Introduction to Sustainability and Entrepreneurship
2) Sustainable Entrepreneurship
3) Opportunity Identification
4) Development of Double and Triple Bottom Line Solutions
5) Forming and Funding of New Sustainable Ventures
6) Market Entry
7) Sustainable Entrepreneurship and Life Sciences - Reflections and Discussion

Intended Learning Outcomes:
Upon successful completion of this module, students will be able to (1) summarize and (2) evaluate the socio-economic problems society is facing. They will (2) match the concept of sustainable entrepreneurship as a promising approach for addressing complex sustainability issues in general, and in the field of life sciences in particular. More specifically, students will (3) be able to identify the venture creation process from opportunity

identification to market entry in the context of sustainability and life sciences. In addition, participants will be able to (4) apply this knowlede to the field of life sciences. Finally, the students will be able to (5) critically evaluate case studies from the field of life sciences and to (6) create own ideas for sustainable ventures in this context.

Teaching and Learning Methods:
The module is a seminar which intends to familiarize the student with the relevant literature and follows an interactive course format with group work assignments and guest lectures. This is the appropriate format for this advanced level module because it encourages the students to go into further detail and to deal with the issues in an integral, interactive and independent way.

Media:
Presentations, slides, cases, links and further literature will be provided via www.moodle.tum.de

Reading List:
Muñoz, P., & Cohen, B. (2018). Sustainable entrepreneurship research: taking stock and looking ahead. Business Strategy and the Environment.

The module is based on key scientific papers on each topic. These form the basis for classroom discussions and are to be used for developing an argument in the reflection essay. All articles are provided as pdf files in TUM Moodle (https://www.moodle.tum.de).

Responsible for Module:
Belz, Frank-Martin; Prof. Dr. oec.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Seminar Life Sciences & Management (WIB14002): Sustainable Entrepreneurship - Theoretical Foundations (seminar, 4 SWS)
Belz F, Gimenez Jimenez D

For further information in this module, please click
campus.tum.de or here.

Elective Modules Modules Life Sciences and Management

Module Description

WI000948: Food Economics

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students prove their achievement of learning outcomes in an oral exam of 30 minutes. The exam is designed to test whether students understand the discussed topics and publications in the field of food economics. Students are asked to describe and explain important trends and phenomena in food markets in Germany, Europe and the world in a meaningful and exact way. In the oral exam they also have to demonstrate their ability to analyze consumer and firm behavior in food markets based on economic theory and show that they are able to assess the effectiveness of food policy instruments. Additionally, students prove they can critically reflect on assumptions, methodology, results, and political and societal implications of research in food economics. An oral exam is the most suitable format to account for the discursive and reflective nature of the abilities examined.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
The course applies microeconomic theory to study questions of food demand and supply. Students should feel comfortable with the material in microeconomic courses at introductory level.

Content:
The course is intended to provide students with in-depth coverage of food economics with an emphasis on trends and phenomena of food markets, food labelling, food safety, food consumption, nutrition and food policy. Taking examples from these domains the course introduces a variety of economic models that are being used in food-economic research.

Intended Learning Outcomes:
At the end of the module, the students are able to (1) outline important trends and phenomena in food markets in Germany, Europe and the world, (2) analyse consumer and firm behavior in food markets based on economic theory, (3) assess the effectiveness of food policy instruments, (4) acquaint themselves with scientific literature in the area of food economics and discuss and evaluate crucial assumptions, choice of methodology and implications of results.

Teaching and Learning Methods:
The module is designed as an interactive lecture where both lecturers and students provide input for discussion. In order to set up a common basis for participants, lecturers present information on major features and trends on food markets and economic concepts used to analyze them. To familiarize themselves with economic research, students read selected journal articles from the field of agricultural and food economics and prepare a short presentation of 15 minutes and a short report of about 2 pages once per semester, summarising the main hypotheses, methods applied, results obtained and implications derived. Subsequent discussions in classroom on assumptions, limitations of data and methods, as well as on different ways to interprete results deepen students'

understanding of the potential and restrictions of research in food economics.

Media:
Slides, textbooks, journal articles, blackboard, collection of summaries of publications.

Reading List:
Lusk, J. L., Roosen, J, & Shogren, J. F. (eds.) (2011). The Oxford handbook of the economics of food consumption and policy. Oxford University Press: New York.
Additional references are provided in the course.

Responsible for Module:
Roosen, Jutta; Prof. Dr. Ph.D.

Courses (Type of course, Weekly hours per semester), Instructor:
Food Economics (WI000948) (lecture, 4 SWS)
Menapace L, Roosen J

For further information in this module, please click
campus.tum.de or here.

Specialization in Technology

Every student must select an engineering / natural sciences specialization and successfully complete modules for a total of 30 credits. The regulations are specific to the selected engineering / natural sciences subject. The following is an example of such a catalog.

Specialization in Technology: Mechanical Engineering (minor)

Every student must select an engineering / natural sciences specialization and successfully complete modules for a total of 30 credits. The regulations are specific to the selected engineering / natural sciences subject.

Module Description

BV350007: Materials in Mechanical Engineering

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students are assessed in a 90-minute written examination. In the written examination students are required to demonstrate their ability to describe concisely, general basic technical knowledge of materials, the specific properties of metals, polymers and ceramic materials and are able to transfer them into practice, as well as the ability to solve arithmetic problems concerning important material-specific properties under time pressure. Apart from a non-programmable pocket calculator, no aids are allowed.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
none

Content:
The lecture teaches about the chemical and physical principles of materials. The materials concerned are steel, non-ferrous metals, thermoplastics, duroplastics, elastomers, ceramics, glass, cement and concrete. Furthermore, the topics of load-dependent and load-independent deformation properties, stress-strain diagrams and strengths in general are discussed. Apart from the mechanical material properties, the production and durability of the materials are also covered. One focal aspect is the topic of material corrosion.

Intended Learning Outcomes:
At the end of the module the students are able to describe the most important materials and to differentiate between them by way of their characteristic properties. They are able to link the material properties to the elementary structure of the materials. They are also able to select a suitable material for a given requirements profile.
Students also acquire competence in describing and selecting relevant tests for the material properties and depending on the material property to be examined as well as analysing test results statistically and evaluating them on the basis of the material requirements.
Targeted case studies should strengthen student's abstraction ability and their skill in transferring that which they have learned to a new problem area.

Teaching and Learning Methods:
In this course the main teaching content is basically taught in the form of a classic lecture with continuous support in the form of a PowerPoint presentation. Particular detailed aspects or aspects important for overall understanding are derived gradually by writing on the board and are explained graphically. This procedure enables students to receive clear and clearly legible presentation of the content and promotes concentrated listening, and therefore the understanding of the students, as they are not diverted by having to continuously write down what is written on the

board. The lecture material is examined in greater depth through regular, brief exercises adjusted to the progress of the lecture, which enables optimum implementation of the lecture content.

Media:
PowerPoint-presentation, overheadprojector, board, experiments, video

Reading List:
- Roos, E; Maile, K.: Werkstoffkunde für Ingenieure. Springer 2005
- Reissner, J.: Werkstoffkunde für Bachelors. Hanser Verlag 2010
- Schneider, J.: Sicherheit und Zuverlässigkeit im Bauwesen. www.vdf.ethz.ch
- Henning/Knöfel: Baustoffchemie. Verlag Bauwesen 2002
- Skriptum zu Vorlesung Baustoffkenngrößen, Bauchemie, Konstruktionswerkstoffe Teil III

Responsible for Module:
Dr.-Ing. D. Lowke: mailto: lowke@tum.de
Dr.-Ing. K. Osterminski mailto: kai.osterminski@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Materials in Engineering (lecture with integrated exercises, 4 SWS)
Kränkel T, Osterminski K

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

MW1108: Engineering Mechanics for Technology Management [TM TUM BWL]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	135	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In a 120-minute written examination, the understanding of the imparted principles and techniques of engineering mechanics is tested by application of them on various problems. These calculation problems are similar in the style to the exercises, where the students are intended to analyse, to systematically tackle and to solve the tasks included.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Good knowledge in applied mathematics. Recommended courses: "Mathematische Behandlung der Natur- und Wirtschaftswissenschaften 1+2" or "Höhere Mathematik"

Content:
Basic principles of statics, elastostatics and kinetics: force, moment (torque), equilibrium, method of sections, center of mass, energy and stability, stress and strain, elastic constitutive law, Mohr's circle, (Euler-Bernoulli) beam theory, area moments of inertia, kinematics and kinetics of particles, impact, vibrations.

Intended Learning Outcomes:
After successful participation the students are able to
- apply terminology, principles and techniques of engineering mechanics
- analyse, tackle and solve new problems out of the covered fields
- create self-dependently particular knowledge in the field of engineering mechanics on the basis of the conveyed fundamentals
- understand subsequent lectures at the faculty of mechanical engineering
- create a level of comunication with engineers in their daily professional life.

Teaching and Learning Methods:
The module consists of a lecture including exercises as well as a tutorial in small groups on a weekly basis. The lecture includes several teaching methods such as presentations, animations, short films and the usage of a blackboard. The current subject matter is repeated in tutorials and further examples are exercised. All teaching and exercise material as well as proposals for solutions and further information can be downloaded from the E-Learning platform.

Media:
Presentations, blackboard.

Documents via E-Learning platform.

Reading List:
Gross - Hauger - Schnell: Technische Mechanik 1, Springer Verlag
Gross - Hauger - Schröder - Wall: Technische Mechanik 2, Springer Verlag
Hauger - Schnell - Gross: Technische Mechanik 3, Springer Verlag
Wriggers - Nackenhorst - Beuermann - Spiess - Löhnert: Technische Mechanik kompakt, Springer-Vieweg-Verlag

Responsible for Module:
Werner, Ewald; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Engineering Mechanics for Technology Management - Exercises (exercise, 1 SWS)
Werner E [L], Krempaszky C (Jahn Y)

Engineering Mechanics for Technology Management (lecture, 2 SWS)
Werner E [L], Krempaszky C (Jahn Y)

Engineering Mechanics for Technology Management - Group Exercises (exercise, 2 SWS)
Werner E [L], Krempaszky C (Jahn Y)

For further information in this module, please click
campus.tum.de or here.

Module Description

MW1694: Machine Elements - Basics, Manufacturing, Application [ME-BMA]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
7	210	135	75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Modulprüfung findet in Form einer schriftlichen Klausur (Bearbeitungsdauer 120 Minuten) statt. Anhand von Verständnisfragen, konstruktiven Zeichnungen und Rechenaufgaben sollen die Studierenden nachweisen, dass sie Verständnis für die grundlegenden Elemente von Maschinen besitzen und dieses auch anwenden können. Sie sollen beispielsweise nachweisen, dass sie Normen anwenden, Toleranzen und Passungen entwickeln, Oberflächengüten bewerten, statische Festigkeitsberechnungen anwenden, stoffschlüssige Verbindungen, wie z. B. Schweißen, Löten, Kleben und Nieten bewerten, Schraub- und Welle-Nabe-Verbindungen entwickeln und Gestaltungsrichtlinien in der Konstruktion anwenden können. Weiterhin kann überprüft werden, ob Paarungen und Lager analysiert und Getriebe verstanden werden können. Schmierungen und Dichtungen sollen erinnert werden. Als Hilfsmittel zur Prüfung wird eine vom Lehrstuhl erstellte Formelsammlung ausgegeben. Des Weiteren sind nicht programmierbare Taschenrechner zugelassen.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Grundlagen der Produktion, Maschinenzeichnen und elastostatische Mechanik

Content:

Intended Learning Outcomes:
Nach der Teilnahme an den Modulveranstaltungen sind die Studieren-den in der Lage grundlegende Zusammenhänge von Maschinenelemen-ten zu verstehen und zu bewerten.
Sie können:
- Normen anwenden, Toleranzen und Passungen entwickeln sowie Oberflächengüten bewerten
- Statische Festigkeitsnachweise anwenden
- Stoffschlüssige Verbindungen, wie z.B. Schweißen, Löten, Kleben und Nieten) bewerten.
- Schraub- und Welle-Nabe-Verbindungen entwickeln
- Gestaltungsrichtlinien in der Konstruktion anwenden
- Paarungen und Lager analysieren
- Getriebe verstehen
- Schmierungen und Dichtungen erinnern

Teaching and Learning Methods:
In der Vorlesung werden die theoretischen Grundlagen zu Maschinene-lementen mittels Vortrag und Präsentation vermittelt. Den Studierenden wird dazu ein Skript zur Verfügung gestellt, in dem sie die Theorie durch eigene Notizen ergänzen können. Mit den Erläuterungen aus der Vorle-sung und entsprechendem Eigenstudium lernen die Studierenden, Nor-men anzuwenden, Toleranzen und Passungen zu entwickeln, Oberflä-chengüten zu bewerten, statische Festigkeitsberechnungen anzuwen-den, stoffschlüssige Verbindungen, wie z.B. Schweißen, Löten, Kleben und Nieten zu bewerten, Schraub- und Welle-Nabe-Verbindungen zu entwickeln und Gestaltungsrichtlinien in der Konstruktion anzuwenden. Paarungen und Lager sollen analysiert und Getriebe verstanden werden können. Schmierungen und Dichtungen sollen erinnert werden.
In der Übung werden Beispielaufgaben gemeinsam mit den Studieren-den berechnet, besprochen und diskutiert. Damit soll erreicht werden, dass die Studierenden sich selbstständig die Lernergebnisse aneignen sowie Transferleistungen erbringen können.

Media:
Präsentation, Filme

Reading List:
Niemann, Gustav; Höhn, Bernd-Robert; Winter, Hans (2005): Maschinenelemente. Entwerfen, Berechnen und Gestalten im Maschinenbau ; ein Lehr- und Arbeitsbuch. 4., bearb. Berlin [u.a.]: Springer.

Responsible for Module:
Zäh, Michael; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Machine Elements and Manufacturing (lecture, 2 SWS)
Zäh M, Busch M, Ellinger J, Meyer S, Sigl M, Zhao X

Machine Elements and Manufacturing (exercise, 3 SWS)
Zhao X, Zäh M, Busch M, Ellinger J, Meyer S, Sigl M

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

MW1903: Bioprocess Engineering

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In einer schriftlichen Klausur (Bearbeitungsdauer 90 min, zugelassenes Hilfsmittel: Taschenrechner) sind die vermittelten Inhalte zu den Grundlagen der Bioverfahrenstechnik auf entsprechende Problemstellungen anzuwenden und auf weiterführende Aufgabenstellungen zu übertragen. Dadurch weisen die Studierenden nach, dass sie die Eigenschaften biotechnischer Verfahren verstehen und bewerten können wie beispielsweise die zu Grunde liegende Formalkinetik oder die Aufteilung biotechnologischer Prozesse in verschiedene Schritte.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Empfohlene Kenntnisse sind Grundlagen der Mathematik, Chemie und Biologie, wie sie in Bachelorstudiengängen an deutschen Hochschulen vermittelt werden.

Content:
In diesem Modul werden die physikalischen, chemischen, biochemischen, biologischen und thermodynamischen Grundlagen biologischer Stoffumwandlungen für Ingenieure vermittelt. 1. Einführung und Grundlegendes über die Bioverfahrenstechnik, 2. physikochemische Eigenschaften des Wassers, 3. Biophysikalische Eigenschaften von Zellen, 4: Biochemische Reaktionssysteme, 5. Bioreaktionstechnik I ¿ Enzymkinetik, 6. Bioreaktionstechnik II ¿ Metabolische Modelle, 7. Bioreaktionstechnik III ¿ Wachstumskinetik, 8. Steril-Verfahrenstechnik, 9. Aufarbeitung von Bioprodukten, 10. Bioprozessanalytik, 11. Industrielle Biotechnologie

Intended Learning Outcomes:
Nach der Teilnahme an dieser Modulveranstaltung haben die Studierenden grundlegende Kenntnisse der Bioverfahrenstechnik erworben und sind in der Lage, die wesentlichen Eigenschaften biotechnologischer Verfahren zu verstehen und zu bewerten. Die Studierenden sind in der Lage die der Bioreaktionstechnik zu Grunde liegende Formalkinetik zu erkennen und diese auf exemplarische Problemstellung anzuwenden. Ebenfalls sind die Studierenden in der Lage, zu erkennen, dass ein biotechnologischer Prozess mit Enzymen und Zellen aus einer Vielzahl verschiedener Schritte (Stoffumwandlung, Aufarbeitung, Steriltechnik, Analytik) besteht.

Teaching and Learning Methods:
In der Vorlesung werden mittels PowerPoint Folien die theoretischen Grundlagen der Bioverfahrenstechnik vermittelt. Wichtige Inhalte werden wiederholt aufgegriffen, um das Verständnis und die Bewertung der Eigenschaften biotechnologischer Verfahren zu stärken. Die Vorlesungsunterlagen werden den Studierenden auf geeignete Weise zur Verfügung gestellt. In der (zeitlich daran anschließenden) Übung werden Übungsaufgaben vorgerechnet und die Musterlösungen den Studierenden ebenfalls zur Verfügung gestellt. Damit und durch gezielte Fragen an den Übungsleiter haben die Studierenden die Möglichkeit ihr Verständnis zu vertiefen, um beispielsweise die der Bioreaktionstechnik zu Grunde liegende Formalkinetik sowie die Aufteilung

biotechnologischer Prozesse in verschiedene Schritte zu erkennen.

Zur Verfügung gestellt werden Powerpoint-Folien (via Beamer) als Vorlesungs- und Übungsunterlagen und Musterlösungen zu den Übungsaufgaben.

Media:
Die in der Vorlesung verwendeten Folien werden den Studierenden in geeigneter Form rechtzeitig zugänglich gemacht. Übungsaufgaben werden regelmäßig verteilt und in der Regel werden die Musterlösungen eine Woche später ausgegeben und mit den Studierenden diskutiert.

Reading List:
Es ist kein Lehrbuch zu allen Inhalten dieses Moduls verfügbar. Als Einführung empfiehlt sich: Horst Chmiehl: Bioprozesstechnik. Elsevier GmbH, München.

Responsible for Module:
Weuster-Botz, Dirk; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Bioprocess Engineering (lecture, 3 SWS)
Weuster-Botz D [L], Weuster-Botz D, Wolf L

For further information in this module, please click
campus.tum.de or here.

Module Description

MW1918: Industrial Software Engineering

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor/Master	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Das Erreichen der Lernergebnisse wird mit einer 90-minütigen, schriftlichen Prüfung überprüft. In dieser soll nachgewiesen werden, dass die Studierenden die gelehrten theoretischen sowie praktischen Grundlagen für die Erstellung von industrieller Software abrufen und wiedergeben, das Verstehen und Anwenden von Modellierungsansätzen wie der unified modeling language (UML) zeigen und Grundlagen über die Implementierung von Modellen mittels Programmiersprachen (z.B. C++) nachweisen können. Daneben müssen die Studierenden auch Anforderungen und Spezifikationen an industrielle Software selbstständig analysieren bzw. definieren, Fragen und Herausforderungen bezüglich der Qualitätssicherung von Software beantworten und die Grundlagen für die Anwendung und Konstruktion von Datenbanken wiedergeben können.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Grundlagen der modernen Informationstechnik

Content:
Die Vorlesung "Industrielle Softwareentwicklung für Ingenieure" vermittelt, aufbauend auf dem Modul "Grundlagen der modernen Informationstechnik", weitere Kenntnisse der Softwareentwicklung, die den späteren Ingenieur bei der Entwicklung von softwareintensiven Produkten unterstützen. Die Vorlesung behandelt zum einen das methodische Vorgehen bei der Softwareentwicklung, wie Vorgehensweisen, Phasenmodelle und qualitätssichernde Maßnahmen. Zum anderen sollen Modellierungstechniken, Programmierparadigmen sowie geläufige Architekturmuster für das Design moderner Software vermittelt werden. Auch Datenbanken inklusive deren Beschreibungsmitteln und Abfragesprachen werden den Studierenden vermittelt. Bei der Gestaltung der Vorlesung wurde großer Wert auf den engen Bezug der Inhalte zum Maschinen- und Anlagenbau und zu aktuellen Forschungsergebnissen und Entwicklungen gelegt. In der Vorlesung werden vorwiegend Methoden und Konzepte für die Analyse und das Design moderner Software vorgestellt. In der vorlesungsbegleitenden Übung wird das Erlernte durch den praktischen Einsatz von Entwicklungswerkzeugen und Programmiersprachen (wie C++) vertieft. Beispielaufgaben von der Anforderungsanalyse über die Modellierung und Implementierung bis hin zum Test der Software ermöglicht es den Softwareentwicklungsprozess in den Übungen praxisnah zu erfahren.

Intended Learning Outcomes:
Nach der Teilnahme am Modul industrielle Software-Entwicklung für Ingenieure sind die Studierenden in der Lage Systeme, ausgehend der Ermittlung und Analyse der Anforderungen, selbstständig durch Anwendung von Modellierungstechniken (wie UML) zu beschreiben und bewerten. Des Weiteren kennen die Studierenden methodische Vorgehensweisen für die Softwareentwicklung und können diese in unterschiedlichen Kontexten anwenden. Auch unterschiedliche Architekturmuster und Designs moderner Software sind den Studierenden bekannt.

Darüber hinaus sind die Studierenden in der Lage, ausgehend ihrer selbsterstellten Modelle, eigenständig Implementierungen (z.B. unter Verwendung von C++) zu entwickeln. Das Messen der Komplexität sowie die Analyse von etwaigen Fehlern werden ebenfalls von den Studierenden beherrscht.
Weiterhin besitzen die Studierenden Kenntnisse für die Analyse und Konstruktion von Datenbanksystemen wie sie bei Projekten mit großen Datenmengen für die effiziente, widerspruchsfreie und dauerhafte Speicherung und Bereitstellung der Informationen benötigt werden.

Teaching and Learning Methods:
In der Vorlesung werden durch Vortrag und Präsentation die theoretischen Zusammenhänge erläutert und Fallstudien anhand von praktischen Beispielen vorgestellt. Damit lernen die Studierenden z. B. die gelehrten theoretischen sowie praktischen Grundlagen für die Erstellung von industrieller Software abzurufen und wiederzugeben. Die zugehörige Übung umfasst das Lösen von Aufgaben zu den Themen der Vorlesung in Einzel- und Gruppenarbeit zur Bearbeitung von Problemen und Lösungsfindung. Praktische Übungen dienen der Vertiefung von Programmier- und Modellierfertigkeiten sowie der Erlernung der Zusammenarbeit mit anderen. Lösungsvorschläge werden zusätzlich im Rahmen von Vorträgen und Präsentationen aufgezeigt. Damit lernen die Studierenden beispieslweise, Systeme, ausgehend der Ermittlung und Analyse der Anforderungen, selbstständig durch Anwendung von Modellierungstechniken (wie UML) zu beschreiben und zu bewerten sowie ausgehend ihrer selbsterstellten Modelle, eigenständig Implementierungen (z.B. unter Verwendung von C++) zu entwickeln. Das Messen der Komplexität sowie die Analyse von etwaigen Fehlern werden ebenfalls von den Studierenden beherrscht.

Media:
Präsentation, Tafelübungen, praktische Übungen (Modellieren, Programmieren),
Videomaterial zum tieferen Verständnis

Reading List:
- Vogel-Heuser, B.: Systems Software Engineering. Angewandte Methoden des Systementwurfs für Ingenieure. Oldenbourg, 2003. ISBN 3-486-27035-4.
Partsch, Helmut: Requirements Engineering systematisch, Modellbildung für softwaregestützte Systeme, Springer, 1998.
- Oestereich, Bernd: Analyse und Design mit UML 2.1
- Zöbel, D.; Albrecht, W.: Echtzeitsysteme. Grundlagen und Techniken. International Thomson Publishing, 1995.
- Stevens, R.; Brook, P.; Jackson, K.; Arnold, S.: Systems Engineering. Coping with Complexity. Prentice Hall Europe, 1998.
- Ian Sommerville: Software Engineering, 2012.
- Chris Rupp, Stefan Queins: UML 2 glasklar: Praxiswissen für die UML-Modellierung, 2012.
- Helmut Erlenkötter: Objektorientiertes Programmieren von Anfang an, 2005.
- Bjarne Stroustrup: Einführung in die Programmierung mit C++, 2010.

Responsible for Module:
Vogel-Heuser, Birgit; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Industrial software development for engineers (exercise, 1 SWS)
Vogel-Heuser B

Industrial software development for engineers (lecture, 2 SWS)
Vogel-Heuser B

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

MW1932: Basics of Casting and Metal Forming [GdUU]

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	100	50

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die vermittelten Lehrinhalte sind in einer schriftlichen Prüfung auf verschiedene Problemstellungen anzuwenden.

Repeat Examination:
Next semester

(Recommended) Prerequisites:

Content:
Die Vorlesung Grundlagen der Ur- und Umformtechnik soll den Studierenden als Einführung in die wissenschaftlichen Themenschwerpunkte des Lehrstuhls für Umformtechnik und Gießereiwesen (utg) dienen. Nach Vorstellung der geschichtlichen Grundlagen der Ur- und Umformtechnik werden im Verbund mit dem notwendigen werkstofftechnischen Basiswissen die Grundzüge der beiden Hauptgruppen Ur- und Umformen nach DIN 8580 behandelt. Ebenfalls wird das die meisten industriellen Umformprozesse begleitende spannlose Trennverfahren mit geometrisch bestimmter Schneide Zerteilen beleuchtet.
Abgerundet wird die Vorlesung mit ökonomischen Problemkomplexen der Umformtechnik.

Intended Learning Outcomes:

Teaching and Learning Methods:
Die Lehrinhalte der Vorlesung werden in Vorträgen und Präsentationen vermittelt. Ergänzt werden diese durch die Übung, in der konkrete Probleme aus der Praxis vorgerechnet werden. Die Lehrmaterialien werden online zur Verfügung gestellt.

Media:
Vortrag, Präsentation, Tablet-PC mit Beamer

Reading List:
Spur, G.: Handbuch der Fertigungstechnik, Band 2 Umformen und Zerteilen, Carl Hanser Verlag

Lange, K.: Umformtechnik: Handbuch für Industrie und Wissenschaft, Springer Verlag

Doege, E.: Handbuch Umformtechnik, Springer Verlag

Responsible for Module:
Neumayer, Franz Ferdinand; M.Sc.

Courses (Type of course, Weekly hours per semester), Instructor:
Metal Forming (lecture, 3 SWS)
Böhm L [L], Volk W

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

MW2013: Basics of Machines Drawing and Computer Aided Design 2 [CADundMZ]

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Bachelor/Master	German	two semesters	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
3	150	45	105

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Das Lernergebnis im Modul CAD und Maschinenzeichnen wird durch zwei Modulteilprüfungen geprüft: eine Prüfungsleistung in Form einer schriftlichen Klausur mit einer Dauer von 90 Minuten, die regulär am Ende des Sommersemesters abgehalten wird und einer Studienleistung in Form einer Übungsleistung bestehend aus dem Anfertigen von technischen Zeichnungen und CAD Konstruktionsaufgaben.
In der Klausur wird geprüft, inwieweit die Studierenden in der Lage sind eigene technische Zeichnungen anzufertigen, moderne CAD-Systeme und deren Modellierungsansätze softwareunabhängig zu beherrschen und Fragestellungen hinsichtlich einer sinnvollen Gestaltung von Konstruktionen anhand von Beispielen zu beantworten. Neben dem üblichen Schreibmaterial sind in der Prüfung Zeichenstifte, Bleistifte, Zirkel, Lineale und die Kreisschablone als Hilfsmittel zugelassen. Durch die schriftliche Klausurform wird eine praxisnahe Prüfung der erlernten Fähigkeiten sichergestellt. Die Prüfungsnote gilt als Modulnote.
Die Übungsleistung beinhaltet die Bearbeitung von vorgegebenen Aufgaben, die sich über das Winter- und das Sommersemester erstrecken, aus den Komponenten CAD-Einführung sowie Skizzier- und Darstellungstechniken. Die Möglichkeit die Aufgaben aus "CAD-Einführung" zu bearbeiten, wird regulär im Wintersemester angeboten. Die Studierenden sollen zeigen, dass sie in der Lage sind CAD-Konstruktionen und technische Zeichnungen zu erstellen. Diese Aufgaben werden in Heimarbeit bearbeitet, wobei Bauteile und Baugruppen in CAD modelliert werden sollen. An Präsenzterminen werden dazu in einem Umfang von vier Testaten (je circa 15-20 min) die Modellierungen überprüft. Die Bewertung der Bauteile und Testate erfolgt durch CAD-erfahrene Mitarbeiter des Lehrstuhls.
Die Möglichkeit die Aufgaben zu "Skizzier- und Darstellungstechniken" zu bearbeiten, erfolgt im Sommersemester. Dazu erstellen die Studierenden technische Zeichnungen von Maschinenbauteilen. Die Überprüfung der Zeichnungen erfolgt nach einem auf der moodle-Plattform zugänglichen Kriterienkatalog, erstellt durch Mitarbeiter des Lehrstuhls.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Keine Voraussetzungen nötig. Da das Modul zweisemestrig ist, gelten die Lehrveranstaltungen im WiSe als Voraussetzung für die Lehrveranstaltungen im SoSe.

Content:
Die Vorlesung "Technisches Zeichnen" im WS vermittelt die Regeln des Technisches Zeichnens. Folgende Lehrinhalte werden vermittelt:
- Grundlagen der Zeichnungserstellung
- Darstellung eines Bauteils
- Bemaßung von Bauteilen
- Oberflächen-, Kanten- und Härteangaben

- Toleranzen und Passungen
- Fügeverbindungen, Schmieden, Gießen
- Normteile
- Freihandzeichnen

Im Praktikum "CAD-Einführung" im WS werden die Grundlagen der Arbeit mit CAD-Systemen gelehrt. Neben der Erstellung von Bauteilen, Baugruppen und Zeichnungen im 3D und 2D Bereich wird sukzessive das Wissen aus der Vorlesung vertieft. Der Schwerpunkt des zweiten Teils von CAD und Maschinenzeichnen liegt in der Vorlesung "Konstruktive Gestaltungslehre" im SS. Diese Vorlesung vermittelt prinzipielle Gestaltungsregeln bei der Konstruktion von Bauteilen. Dazu werden neben den Grundregeln der Gestaltungslehre, fertigungsspezifische Gestaltungsregeln sowie Hinweise zur Montage- und belastungsgerechten Gestaltung gegeben.

Das Praktikum "Skizzier- und Darstellungstechniken" im SS lehrt durch Bauteilaufnahmen die praktische Anwendung der Regeln des technischen Zeichens.

Intended Learning Outcomes:
Die Studierenden sind nach erfolgreichen Abschluss des Moduls ¿CAD und Maschinenzeichnen (für TUM-BWL, TUM-Witec und IN)¿ in der Lage,
- eine komplexe technische Zeichnung zu analysieren,
- den Zusammenhang von Bauteil- und Zusammenstellungszeichnungen zu analysieren,
- technische Zeichnungen und deren Auswirkungen hinsichtlich Fertigung, Kosten, etc. zu analysieren sowie diese unter Beachtung aller einschlägigen Richtlinien und Normen selbstständig anzufertigen (=schaffen),
- den Einfluss von verschiedenen Fertigungsverfahren auf die Gestaltung von Bauteilen zu bewerten,

Teaching and Learning Methods:
Die Vorlesungen des Moduls CAD und Maschinenzeichnen erfolgen als Frontalunterricht, ergänzend können die Inhalte im eLearning-Angebot selbst erarbeitet bzw. vertieft werden.

In den Zentralübungen werden die Inhalte der Vorlesung wiederholt und durch Übungsaufgaben angewendet. Die Studenten sind zur aktiven Mitarbeit aufgefordert.

Die Lernziele des Praktikums "CAD-Einführung" werden in der Gruppenarbeit nach dem Ansatz des problembasierten Lernens und des Arbeitsunterrichts vermittelt.

Das Praktikum "Skizzier- und Darstellungstechniken" ist als Arbeitsunterricht konzipiert, in dem die Studenten selbstorganisiert individuelle Aufgaben lösen müssen.

Media:
- Skripten zu allen Veranstaltungsteilen
- Präsentationen
- Übungsblätter
- Lehrvideos
- e-Learning
- Aufgaben und Lösungen

Reading List:
- Skripten des Lehrstuhls fml
- Unterlagen auf moodle-Plattform
- Hoischen, H.; Fritz, A.: Technisches Zeichnen; Berlin, Cornelsen 2018, 36. Auflage; ISBN: 978-3-06-451712-7

Responsible for Module:
Günthner, Willibald; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Technical Drawing and Introduction to CAD (practical training, 2 SWS)

Fottner J (Kessler S, Kleeberger M, Mitarbeiter W, Pfeiffer M, Rücker A, Tan Y)

CAD and Machines Drawing 2 (lecture, 1 SWS)
Fottner J (Kessler S, Pfeiffer M, Rücker A)

Technical Drawing and Introduction to CAD (exercise, 1 SWS)
Fottner J (Pfeiffer M, Rücker A, Tan Y)

For further information in this module, please click
campus.tum.de or here.

Module Description

MW2016: Basics of Machines Drawing and Computer Aided Design 1 [CAD & MZ I]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
2	60	30	30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The material covered in the course will be examined by a study task. The lab course CAD Introduction will examine the practical application of the material covered in the course technical drawing . The assessment of the students practical understanding will be carried out during two compulsory attendance days, which have to be passed successfully.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
No requirements

Content:
The course Technical Drawing covers the basic principals of technical drawing. The following content will be covered:

- Preparation of drawings
- Drawing of engineering components
- Dimensioning of engineering components
- Surface, flange and hardness declarations
- Tolerances and fits
- Join connections, forging, casting
- Standard parts
- Freehand sketching

The lab course CAD Introduction covers the basics of working with CAD-software. In addition to creating engineering components (single and in groups) and their two and three dimensional drawings, the material of the technical drawing course is covered in more detail.

Intended Learning Outcomes:
Having successfully completed the module CAD and Technical Drawing I the students are able to

- Analyse a complex technical drawing
- Comprehend the assembly of technical drawings
- Analyse the connections between device and assembly drawings
- Prepare simple technical drawings
- Work with modern CAD-software

Teaching and Learning Methods:
The course "Technical drawing takes place as student-centered course. Additionally, the contents can be acquired on eLearning.

The tutorial broadens the lecture s contents by practical exercises. The students are asked to contribute actively to the subject.

The learning targets of the lab course CAD Introduction" are provided in group work according to problem-based learning and pracitcal class.

Media:
- Script
- Presentations
- Excercises and solutions
- eLearning

Reading List:
- Provided scripts of the institut fml
- Documents on elearning.tum.de
- eLearning offers of the institut fml
- Hoischen, H.; Hesser, W.: Technisches Zeichnen; Berlin: Cornelsen 2009, 32. Auflage; ISBN: 978-3-589-24132-3

Responsible for Module:
Günthner, Willibald; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
CAD and Machines Drawing 1 (lecture, 1 SWS)
Fottner J (Kessler S, Pfeiffer M, Rücker A)

CAD and Machines Drawing 1 / Practical Course (all students) (exercise, 1 SWS)
Fottner J (Pfeiffer M, Rücker A, Tan Y)

CAD and Machines Drawing I / Practical hours, Tuesday (practical training, 1 SWS)
Rücker A [L], Fottner J, Pfeiffer M

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

MW2021: Fluid Mechanics 1 [FMI]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	75	75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination performance will be brought through a written exam (90 Minutes netto-elaborating time), where the achievement of all learning results of the module is proofed.
In a short question part the students should answer knowledge- and comprehension question in short phrases and proof, that they master the basics and contexts of inviscid and simple viscous flows.
In a calculation part should be proofed, that the students are able to recognize in a limited time and with limited tools the problems of fluid mechanics and find ways to their correct solution. There the students should demonstrate that they can quantitatively describe and analyse inviscid and simple viscous flows (incompressible and compressible).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Mathematics I, II and III; Technical Mechanics I and II, Thermodynamics

Content:
The module Fluid Mechanics I mediates the basics of mechanics of gases and fluids and belongs therefore to the field of classical mechanics as part of engineering education. Based on the content of the module Fluid Mechanics I further lectures in the following semesters with the following contents could be attended:: (1) Physics of fluids, (2) Kinematics of fluids, (3) Conservation laws for mass and momentum, (4) The Bernoulli-equation, (5) Conservation law for energy, (6) Navier-Stokes-equations, (7) Turbulence, (8) Technical Flows.

Intended Learning Outcomes:
After having successfully passed the exam of the module Fluid Mechanics I the students will have on their disposal:
1. Knowledges about the basic kinematic behaviour of liquid and gaseous medias
2. The ability of kinematic flow description
3. The ability to analyse the dynamics of fluids using the conservation laws of mass, momentum and energy
4. The ability to decribe and analyse simple compressible flows
5. The ability to find simple exact solutions to Navier-Stokes -Equations
6. The penomenological comprehension of the effects of friction and turbulence
7. The ability to analyse technical fluids

Teaching and Learning Methods:
In the lecture series the teaching contents are mediated through lecture, presentation and board notes with slides, Tablet-PC and Beamer. The theory is visualised through examples and important context is derived step by step. The students have access via Internet to a slide collection, a supplementing script, a collection of exercises. The students are encouraged to solve the exercises themselves. The associated proposed solution will be presented during the central tutorial via Tablet-PC and/or board notes and will be discussed in context with the theoretical basics of the lecture.
In group tutorials the problem-solving competences of the students will be enhanced by solving additional exercises. In particular, the ability to apply solution strategies to similar problem descriptions are promoted.

Media:
Multimedial supported frontal teaching

Reading List:
Lecture script, lecture slides, exercise collection. Kundu & Cohen "Fluid Mechanics . Spurk "Strömungslehre". Durst "Grundlagen der Strömungsmechanik". Kuhlmann "Strömungsmechanik".

Responsible for Module:
Adams, Nikolaus; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Fluid Mechanics 1 (MW2021) (lecture, 3 SWS)
Adams N (Stemmer C, Giglmaier M, Schmidt S), Lang C

Group exercise on Fluid Mechanics I (exercise, 2 SWS)
Lang C (Giglmaier M), Schmidt S

Exercises on Fluid Mechanics I (MW2021) (exercise, 1 SWS)
Schmidt S (Adams N, Giglmaier M), Stemmer C

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

MW2156: Metal-cutting Manufacturing Processes [SFV]

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Bachelor/Master	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsdauer beträgt 90 min und teilt sich in zwei Blöcke à 45 min. Der erste Block besteht aus einem Kurzfragen- und Berechnungsteil, im zweiten Block ist ein Arbeitsplan zu erstellen. Beide Blöcke sind in etwa gleich gewichtet. Hilfsmittel: Im Kurzfragen- und Berechnungsteil ist nur ein nicht-programmierbarer Taschenrechner erlaubt; eine Formelsammlung wird gestellt. Im Arbeitsplanungsteil sind alle Hilfsmittel erlaubt. "Normale" Wörterbücher sind erlaubt, elektronische Wörterbücher und Fachwörterbücher sind nicht erlaubt.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Lesen und Verstehen von technischen Zeichnungen

Content:
Zu Beginn der Vorlesung werden die Grundlagen der Zerspanungslehre (Kinematik, Schneidteilgeometrie, Spanbildung und Spanarten, Schnittkraftberechnung, Schneidstoffe) behandelt. Darauf aufbauend werden spanende Fertigungsprozesse mit geometrisch bestimmter Schneide (Drehen, Fräsen, Sägen, Bohren, Räumen) und mit geometrisch unbestimmter Schneide (Schleifen, Honen, Läppen) sowie Verfahren zur Gewinde- oder Verzahnungsherstellung besprochen. Ein vergleichender Überblick über abtragende Fertigungsverfahren (Funkenerosion, Laserbearbeitung, Wasserstrahl- und Brennschneiden) schließt die Vorlesung ab. In den einzelnen Kapiteln werden zudem die entsprechenden Werkzeugmaschinen kurz vorgestellt.

Die Vorlesungsinhalte werden im Rahmen einer Übung vertieft. Wesentliche Inhalte der Übung sind die Berechnung von Schnittkräften zur Auslegung von Maschinen und Prozessen sowie die Erstellung von Arbeitsplänen für die spanende Fertigung.

Die Praxisrelevanz der vermittelten Inhalte wird im Rahmen einer Exkursion aufgezeigt.

Intended Learning Outcomes:
Nach der Teilnahme an den Modulveranstaltungen sind die Studierenden in der Lage:

- die Möglichkeiten und Grenzen der vorgestellten spanenden Fertigungsverfahren und der dazugehörigen Werkzeugmaschinen zu bewerten,
- spanende Fertigungsprozesse rechnerisch zu dimensionieren und
- die Fertigungsplanung inklusive Verfahrensauswahl anhand von technischen Zeichnungen durchzuführen.

Teaching and Learning Methods:
Vorlesung:
- Vorträge
- Präsentationen

Übung:
- Vorträge
- Präsentationen
- Gruppen- und Einzelarbeit

Media:
Zur Vorlesung exisitiert ein umfangreiches Skript, das durch eine Präsentation unterstützt wird.

Die Vorlesungsinhalte werden zudem anhand von zahlreichen Videos und Exponaten veranschaulicht.
Sämtliche Übungsunterlagen (inklusive der Musterlösung) werden den Studierenden zum Download angeboten.

Reading List:
Empfohlene Literatur:
- Fischer: Tabellenbuch Metall, Europa Lehrmittel
- Dillinger; Doll: Fachkunde Metall, Europa Lehrmittel
- Hesser; Hoischen: Technisches Zeichnen, Cornelsen
- Degner; Lutze; Smejkal: Spanende Formung, Hanser

Responsible for Module:
Zäh, Michael; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Exercise Courses for Metal-cutting Manufacturing Processes (exercise, 1 SWS)
Zäh M, Fuchs C, Wimmer M

Metal-cutting Manufacturing Processes (lecture, 2 SWS)
Zäh M, Fuchs C, Wimmer M

For further information in this module, please click
campus.tum.de or here.

Specialization in Technology: Mechanical Engineering (major)

Module Description

MW0036: Factory Planning

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the written examination (90 min) students have to remember learned concepts as well as apply and analyse tools and methods without any helping material. I order to answer the questions it is necessary to partly use own words as well as partly solving calculation tasks.The written examination consists of short comprehension questions and calculations. The same number of points can be reached in both examination parts, so that the weight assigned to part 1 and part 2 is 50% each.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
none

Content:
The lecture covers the following aspects of factory planning:
- Objectives of factory planning projects
- Choice of location
- Factory structure and factory layout planning
- Production and assembly planning
- Logistics planning
- Lean production philosophy and methods
- Assessment of factory planning projects
- Digital tools for factory planning

Intended Learning Outcomes:
Participating students are enabled to
... remember the historical development of facility planning and bring the according planning process in line with corporate planning.
... identify the circumstances that necessitate the redesign respectively retrofit of a factory and name possible according objectives.
... to conduct a location planning with the aim of inducing a location decision.
... develop factory layouts as well as logistics, production and assembly systems based on the taught methods.
... remeber the fundamentals of the development and introduction of lean production and improve production systems by applying the according methods.
... apply the methods to assess the cost effectiveness of production concepts.

Teaching and Learning Methods:
- Presentation by lecturer
- Industrial presentation by guest lecturer

Media:
- Lecture script
- Lecture slides
- Case-oriented exercises

Reading List:
Wiendahl, H.-P.; Reichardt, J.; Nyhuis, P.: Handbuch Fabrikplanung: Konzepte, Gestaltung und Umsetzung wandlungsfähiger Produktionsstätten; München: Carl Hanser Verlag, 2009

Grundig, C.-G.: Fabrikplanung: Planungssystematik, Methoden, Anwendung; München: Carl Hanser Verlag, 2009

Womack, J. P.; Jones D. T.: Lean Thinking; Ballast abwerfen, Unternehmensgewinne steigern; Campus-Verlag, 2004

Responsible for Module:
Reinhart, Gunther; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Factory Planning (lecture, 2 SWS)
Reinhart G (Dillinger F, Hofer A), Dillinger F

Factory Planning Exercises (exercise, 1 SWS)
Reinhart G (Dillinger F, Hofer A), Hofer A

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

MW0101: Product Ergonomics

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Lecture material, presented examples and use-cases, calculations as well as possible industrial talks of guest lecturers will be relevant for the exam. Usually a written essay exam (90 minutes) will take place. However, in some exceptions for all students of one study course an oral exam can be offered, e.g. ERASMUS.
It is allowed to use a non-programmable calculator.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
A former visit of the lectures "Ergonomics" is recommended

Content:
The success of products highly depends on the ability to fulfull the comfort requirements of potential users. Three essential aspects determine a comfortable product: The first one is the so called environmental comfort which includes accoustics, vibrations and climate. The second one refers to the geometry of the product: the spatial properties and the necessary forces have to be adapted to the human body. This is summed up by the term: anthropometric design. The third one is about the information flow between man and machine (compatibility, coding of displays and handles), the so called HMI design. In this context one strives for a simple, intuitive controlling, unambiguous feedback and a low error probability. Using the presented databases, methods, (digital) human models and simulation procedures effects for various persons can be predicted.

Intended Learning Outcomes:
At the end of the module students are able to
- understand the different dimensions of ergonomic product design,
- understand the processes of human information processing (perception, response selection, response execution),
- remember relevant standards of product design,
- analyse poducts in terms of anthropometric and system ergonomical design maxims
- understand the involvement of ergonomists in the product emergence process
- evaluate the design of control elements

Teaching and Learning Methods:
Die Vorlesung erfolgt anhand einer Präsentation, in der die theoretischen Grundlagen behandelt werden. Zur Vorstellung aktueller Entwicklungen aus der Industrie werden auch Experten zu Fachvorträgen eingeladen. In fünf Übungsstunden werden gemeinsam realitätsnahe Fallstudien und Rechenbeispiele bearbeitet. Zur selbständigen

Nachbereitung und Vertiefung wird die angegebene Literatur empfohlen und wichtige Themen diskutiert.

Media:
powerpoint presentations, literature in a library with free access

Reading List:
Schmidtke, Heinz; Bernotat, Rainer (Hg.) (1993): Ergonomie. München [u.a.]: Hanser.

Further reading is included in the lecture notes

Responsible for Module:
Bengler, Klaus; Prof. Dr. phil.

Courses (Type of course, Weekly hours per semester), Instructor:
Ergonomic Product Design (lecture, 2 SWS)
Feldhütter A [L], Bengler K

For further information in this module, please click
campus.tum.de or here.

Module Description

MW0102: Production Ergonomics

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Master	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	108	42

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Lecture material, presented examples and use-cases, calculations as well as possible industrial talks of guest lecturers will be relevant for the exam. Usually a written examination (90 min) will take place. However, in some exceptions for all students of one study course an oral exam can be offered, e.g. ERASMUS.
It is allowed to use a formulary, which will be handed out with the exam, and a calculator.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
We highly recommend to take the class in Ergonomics before joining this course.

Content:
At the end of the module students are able to detect safety hazards within production scenarios and prevent employees from damages to health.
Therefore the first part of the lecture deals with principles of human work and human performance. Afterwards follows an introduction in principles of anatomy, anthropometry, biomechanics and cognition.
The second part of the lecture looks at environmental aspects of production ergonomics. Measuring methods as well as norms and laws are presented and can subsequently be used to design future work stations.
To enable students to analyse work stations appropiately the third part of the lecture provides an introduction in job analysis and timekeeping methods (e.g. MTM - Methods Time Measurement).
Additionally to the description of the above mentioned, classic field of production ergonomics the last part of the lecture tries to give an idea about future operating principles and technologies by introducing the research field of human-robot interaction.

Intended Learning Outcomes:
At the end of the module students are able to:
- reproduce labour law-related norms, guidelines and laws
- understand ergonomic theories, concepts and findings
- apply the percieved knowledge on workplace assessment
- analyse and evaluate workloads arising from the working environment (e.g. climate, noise, lighting, physical workload)

Teaching and Learning Methods:
The lecture is based on a presentations by different speakers. In the practical class, specific topics of the lectures are repeated and intensified due to case studies and calculation examples.

Media:
Powerpoint presentation, Literature in form of scientific publications / papers, field trip

Reading List:
Further specific literature references will be given in the specific presentations and the students' material respectively.

Responsible for Module:
Bengler, Klaus; Prof. Dr. phil.

Courses (Type of course, Weekly hours per semester), Instructor:
Production Ergonomics (lecture, 2 SWS)
Harbauer-Rieß C [L], Bengler K, Knott V, Senner V, Lehsing C

Production Ergonomics Exercise (exercise, 1 SWS)
Harbauer-Rieß C [L], Bengler K, Lehsing C

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

MW0107: Networked Production - Industry 4.0 [IVP 4.0]

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Master	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The written exam (90 min) tests the comprehension of networked production and its main concepts through knowledge questions. The ability to apply state-of-the-art methods to simplified examples and to solve problems with calculation schemes is tested as well. Finally the understanding of networked production in context with other areas of manufacturing engineering is tested through scenario-based exercises.
No aids are allowed.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
- Bachelor degree (mechanical engineering, engineering, TUM-BWL, economic engineering or related)
- basic knowledge in the fields of production, information technology and economics
- ability to solve interdisciplinary problems

Content:
Flexible automation of production, production concepts, control systems on all layers of the automation pyramid, process monitoring and process security, handling systems, information technology in production, CNC controls, PLC controls, cell computers, DNC systems, CAD/CAE/CAP/CAM systems, data exchange via interfaces, simulation, rapid prototyping, ERP and PPS systems, integration of computer based systems (CIM), introduction of CIM concepts, availability of complex production systems, current development in "Industrie 4.0", economic assessment

Intended Learning Outcomes:
After attending the lecture the students will be able:
- to evaluate potentials and drawbacks in the use of networked production systems in manufacturing
-to optimise the process oriented use of automation in enterprises
- to apply current methods of automation in producing enterprises
- to assess the use of automation systems in producing enterprises
- to introduce automation systems in producing enterprises

Teaching and Learning Methods:
- study of technical terms and basic context
- discussion of practical examples
- presentation of the content of teaching in the lectures (with practical examples
- discussion and practical examples in the consolidation exercises

Media:
- PowerPoint presentations in the lectures (contents: pictures, diagrams and definitions)
- lecture notes
- additional slides for the exercises

Reading List:

Responsible for Module:
Reinhart, Gunther; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Networked Production (exercise, 1 SWS)
Reinhart G [L], Paul M, Reinhart G

Networked Production (lecture, 2 SWS)
Reinhart G [L], Paul M, Reinhart G

For further information in this module, please click
campus.tum.de or here.

Module Description

MW1902: Industrial Automation [AT]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor/Master	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Modulprüfung besteht aus einer Prüfungsleistung in Form einer schriftlichen Klausur (90 Minuten). Die Modulnote entspricht der Note der Prüfungsleistung.
Die verbindlichen Regularien, Richtlinien und Rahmenbedingungen über die Prüfungsleistung werden immer zu Beginn der Lehrveranstaltung und des jeweiligen Semesters bekannt gegeben.

Die Studierenden entwerfen in der Prüfung Modelle zur Beschreibung automatisierungstechnischer Anlagen und Prozesse aus verschiedenen Sichten der Automatisierungstechnik (z. B. R&I-Fließbilder oder anlagenspezifische Zustandsdiagramme). Hierbei wird die Anwendung von Modellierungsmethoden und den dahinterliegenden Sprachkonstrukten geprüft (z. B. formalisierte Prozessbeschreibung nach VDI/VDE 3682).
Darüber hinaus verwenden die Studierenden spezielle Modellinformationen, um anhand von Auszeichnungssprachen strukturierte Programme für geeignete Anwendungsfälle der Automatisierungstechnik zu entwerfen (z. B. nach den Sprachen der IEC 61131-3). Die Studierenden klassifizieren und illustrieren nach verschiedenen Verfahren und bewerten Sequenzen gegebener Abläufe der Feldbuskommunikation. Darüber hinaus beurteilen sie die Aspekte der Zuverlässigkeit und Sicherheit automatisierungstechnischer Anlagen anhand zu berechnender Kennwerte. Gestaltungselemente für die Mensch-Maschine-Schnittstellen werden anhand von Anwendungsproblemen geplant und charakterisiert, sowie resultierende Reaktionszeiten durch Berechnungen nachgewiesen.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Grundlagen der modernen Informationstechnik I und II

Content:
Die Lehrveranstaltung "Automatisierungstechnik I" behandelt die zur Automatisierung von Maschinen und Anlagen eingesetzten informationstechnischen Komponenten. Sie gibt dazu zunächst einen Überblick über die vorhandenen Automatisierungsstrukturen und die dazu entsprechenden Systeme sowie Geräte. Die Modellierung der Anlagen bzw. Prozesse wird anhand verschiedener Modellierungsmethoden (z. B.: R&I-Fließbilder) behandelt. Die Strukturierung und Transformation in anwendbare Steuerungsprogramme wird auf Basis von Auszeichnungssprachen gelehrt. Weitere Inhalte sind die Schnittstellen zwischen dem technischen Automatisierungssystem und dem technischen Prozess in Form von Aktoren und Sensoren sowie zwischen Mensch und Maschine durch das Mensch-Maschine-Interface (MMI). Behandelt werden zudem die Themengebiete "Industrielle Kommunikation" (z. B. Feldbussysteme) und die "Steuerung von Maschinen mittels der Sprachen der IEC 61131-3". Wichtiger Bestandteil der Lehrveranstaltung ist das Zusammenwirken der verschiedenen Automatisierungsbausteine im Gesamtsystem. Hierzu wird das methodische Vorgehen bei der

Konzeption, Realisierung, dem Test und der Inbetriebnahme von Automatisierungssystemen sowie deren Beurteilung hinsichtlich Sicherheit und Zuverlässigkeit behandelt. Abgerundet wird die Vorlesung durch eine Einführung in Manufacturing Execution Systems (MES). Das Modul ist weiterhin auf das Erlernen von methodischem Vorgehen sowie den Bezug und die praktische Anwendung aktueller Forschungsergebnisse in der Automatisierungstechnik ausgerichtet.

Intended Learning Outcomes:
Die Studierenden können nach Abschluss des Moduls das Zusammenwirken der verschiedenen Aspekte der Automatisierungstechnik im Kontext des Gesamtsystems bewerten. Daraus ableitend sind die Studierenden in der Lage Anforderungen zu entwickeln. Die Studierenden werden befähigt, sowohl den technischen Prozess als auch das dazugehörige automatisierungstechnische System mit geeigneten Methoden und Modellierungssprachen anzuwenden (z. B. R&I-Fließbilder, Zustandsdiagramme, etc.).
Darüber hinaus können sie die Mechanismen von industriellen Echtzeit-, Bus- und Betriebssystemen selbst einsetzen und Automatisierungssysteme mit den IEC 61131-3 konformen Sprachen programmieren. Außerdem sind sie in der Lage, die Funktionsweise sowie das Wirkprinzip von Aktoren und Sensoren für die Analyse bzw. Planung von Automatisierungssystemen zu bewerten.
Die Studierenden werden zudem die Fähigkeit erwerben, die Zuverlässigkeit und Sicherheit automatisierungstechnischer Anlagen zu analysieren und Mensch-Maschine-Schnittstellen unter Berücksichtigung weit verbreiteter und akzeptierter Gestaltungsrichtlinien selbstständig zu entwickeln. Darüber hinaus können sie die Informationsflüsse eines Manufacturing Execution Systems (MES) auf Basis von spezifischen Modellen planen.

Teaching and Learning Methods:
In der Vorlesung werden durch Vortrag und Präsentation die theoretischen Zusammenhänge erläutert und anhand von Fallstudien aus der realen Praxis vorgestellt. Mittels Präsentationen wird die frontale Wissensermittlung ermöglicht. Die dazugehörige Übung umfasst das Lösen von entsprechenden Aufgaben (von Verständnisfragen über Rechenaufgaben bis hin zur Anwendung geeigneter Methoden und Modellierungssprachen). Diskussionsrunden, Gruppenarbeit und aktive Teilnahme ermöglichen ein tieferes Verstehen der Vorlesungsinhalte und deren Anwendung.

Media:
Präsentation, Tafelübungen, praktische Übungen (Modellieren, Programmieren),
Videomaterial zum tieferen Verständnis

Reading List:
- Vogel-Heuser, B.: Systems Software Engineering. Angewandte Methoden des Systementwurfs für Ingenieure. Oldenbourg, 2003. ISBN 3-486-27035-4.
- Partsch, Helmut: Requirements Engineering systematisch, Modellbildung für softwaregestützte Systeme, Springer, 1998.
- Zöbel, D.; Albrecht, W.: Echtzeitsysteme. Grundlagen und Techniken. International Thomson Publishing, 1995.
- Stevens, R.; Brook, P.; Jackson, K.; Arnold, S.: Systems Engineering. Coping with Complexity. Prentice Hall Europe, 1998.
- Tiegelkamp, M.; John, K.-H.: SPS Programmierung mit IEC1131-3. Springer-Verlag, Berlin, Heidelberg 1997
- Frevert, L.: Echtzeit-Praxis mit PEARL. Leitfäden der angewandten Informatik. B.G. Teubner, Stuttgart, 1985.
- Lauber, R.; Göhner, P.: Prozessautomatisierung 1. Springer-Verlag, Berlin, Heidelberg 2013.
- Friedenthal, S.; Moore, A.; Steiner, R.: A Practical Guide to SysML; Elsevier, 2011.

Responsible for Module:
Vogel-Heuser, Birgit; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Industrial Automation 1 (lecture, 2 SWS)
Bi F, Vogel-Heuser B

Excercise Industrial Automation 1 (exercise, 1 SWS)
Vogel-Heuser B

For further information in this module, please click
campus.tum.de or here.

Module Description

MW1919: Lightweight Structures [LB]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	75	75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination will be a 90-minute written exam which includes both short questions and problems. In the exam, students demonstrate to what extent they understand and recognize typical problems of lightweight structures and propose and evaluate suitable design solutions. By solving problems, the candidates should demonstrate that they are able to provide the necessary proof of strength and usability for a simple lightweight structure.
Students are allowed to use a non-programmable scientific calculator and a one-sided DIN A4 sheet with arbitrary handwritten or printed notes in the examination.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
keine

Content:
The focus of this course is on structural elements, design methods and materials of lightweight structures. The mathematical theories of statics and dynamics of line elements (bars, beams) and surface elements (discs, plates) are presented and analytical solutions of the underlying differential equations for simple problems are derived. The concept of strength of metallic materials is reviewed and extended by the influence of cyclic loading. Stability is treated by studying buckling of slender beams and buckling of plates and thin-walled structures. Another focus of this course will be vibrations that are of particular importance in lightweight structures due to the susceptibility to vibration of many slender and thin-walled structures (wings, rotor blades). On the basis of practical applications, for example from the aerospace industry, automotive engineering, wind industry and sport devices, the various requirements on lightweight structures will be highlighted and the different views on lightweight design (material, shape and system perspective) will be discussed. Furthermore, the application of the presented design and calculation methods is illustrated.

Intended Learning Outcomes:
You are able to describe the structural mechanics of real lightweight structures by means of simplified surrogate models simple enough to be studied with reasonable effort. You can calculate stresses and strains in simple line and surface structures subject to basic load cases. You understand the causes of stability failure of line and surface elements and you are able to identify measures to increase the stability limits. You can determine the stability limit values for simple geometries and loadings. You can evaluate the influence of cyclic loading on the service life and serviceability of a component and you are familiar with simple methods for fatigue strength verification. You know the materials most frequently used in lightweight structures, you can describe their essential material properties and also evaluate their suitability for a given application. You are able to identify and evaluate relevant design features and design methods of lightweight structures and to compare them with alternative

solution concepts.

Teaching and Learning Methods:
The content of this classed is taught by means of a lecture, presentation slides and formulas written on the blackboard. In addition, essential results are summarized on slides using a tablet PC and provided to the students via the Moodle online teaching platform. In order to deepen selected theoretical contexts, small calculation examples are presented and their solutions are explained. Supplementary PowerPoint presentations with applications from the field of lightweight structures will provide a practical reference. A tutorial will be offered with academic instructors answering individual questions of the students.

Media:
Vortrag, Präsentation, Tafelanschrieb, Tablet-PC mit Beamer, Online-Lehrmaterialien

Reading List:
Wiedemann, Johannes (2007): Leichtbau. Elemente und Konstruktion. 3. Aufl. Berlin, Heidelberg, New York: Springer.

Linke, Markus; Nast, Eckart (2015): Festigkeitslehre für den Leichtbau. Berlin, Heidelberg: Springer Berlin Heidelberg.

Klein, Bernd (2012): Leichtbau-Konstruktion. Berechnungsgrundlagen und Gestaltung. Wiesbaden: Vieweg+Teubner Verlag / Springer Fachmedien Wiesbaden GmbH Wiesbaden

Responsible for Module:
Zimmermann, Markus; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

MW1921: Material Flow and Logistics [MFL]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students apply the lecture¿s contents in a written exam (duration: 90 minutes) with questions and calculation tasks. The only aid allowed is a non-programmable calculator. In this way, students demonstrate different abilities: to analyze logistics systems, logistics processes and logistics structures; to apply methods for planning of such structures; to understand the key functions of physical logistics.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
none

Content:
From a higher point of view, the module explains the tasks, aims, key indicators and impact factors of logistics. Common structures of production and distribution are presented along with according control strategies. Besides key functions of material flow-transportation, distribution/consolidation, storage, order picking and handling-methods to model material flow systems are taught, e. g. flow charts, graphs, material flow matrices and layouts. Methods to analyze system behavior complete the module; they comprise static dimensioning, event-discrete simulation, queuing theory and the concept of availability.
Additionally, the module contains the following contents:
Logistics systems: Design guidelines; logistical processes, functions, and structures; logistical networks; methods for planning logistical structures
Logistics management: Control and coordination in logistics systems, supply chain management, information management

Intended Learning Outcomes:
Having completed the module, students know about key tasks and aims of logistics. They are able to analyze logistics systems, logistical processes and logistical structures. Furthermore, they can apply methods to plan logistical structures and know means of control and coordination in logistics systems and concepts of information management.
In addition, students understand the key functions of physical logistics and are able to apply methods to depict material flow and to dimension and evaluate logistics systems.

Teaching and Learning Methods:
Contents are explained by lectures and by exemplary applications from industrial practice. Supporting the lectures,

students have access to a detailed collection of slides, exercises and sample solutions.
In tutorials, exercises demonstrate the applicability of the lectures¿ theoretical contents.
All documents and further information are accessible online and free via elearning. During office hours of scientific staff, individual questions and problems can be discussed.

Media:
Lectures: Talk with tablet and projector, board and overhead projector; printed scriptum (fee-based)
Online documents: Documents for exercises with sample solutions; scriptum (digital as PDF, free of charge)

Reading List:
Aggteleky, B.: Fabrikplanung: Werksentwicklung und Betriebsrationalisierung, Band 1-3. München, Wien: Hanser, 1987 (Band 1) und 1990 (Band 2 und 3)
Arnold, D.: Materialflusslehre. Braunschweig, Wiesbaden: Vieweg, 1998
Dangelmaier, W.: Fertigungsplanung. Düsseldorf: VDI-Verlag, 2001
Gudehus, T.: Logistik: Grundlagen, Strategien, Anwendungen. Berlin u.a.: Springer, 2005
Großeschallau, W.: Materialflussrechnung. Berlin u.a.: Springer, 1984
Kettner, H., Schmidt, J., Greim, H.-R.: Leitfaden der systematischen Fabrikplanung. München, Wien: Hanser, 1984
Jünemann, R.: Materialfluss und Logistik: Systemtechnische Grundlagen mit Praxisbeispielen. Berlin u.a.: Springer, 1998
Jünemann, R., Schmidt, T.: Materialflusssysteme: Systemtechnische Grundlagen. Berlin u.a.: Springer, 1999
Pfohl, H.-C.: Logistiksysteme: Betriebswirtschaftliche Grundlagen.
Berlin u.a.: Springer, 2004
VDI-Gesellschaft Fördertechnik Materialfluss Logistik (Hrsg.).
VDI-Handbuch Materialfluss und Fördertechnik: Band 1   8.
Düsseldorf: VDI-Verlag
Wildemann, H.: Logistik Prozessmanagement. München: TCW Transfer-Centrum, 2005
Wiendahl, H.-P.: Fertigungsregelung: Logistische Beherrschung von Fertigungsabläufen auf Basis des Trichtermodells. München, Wien: Hanser, 1997

Responsible for Module:
Fottner, Johannes; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Material Flow and Logistics (lecture, 2 SWS)
Vaskovits N [L], Fottner J

Material Flow and Logistics - Exercises (exercise, 1 SWS)
Vaskovits N [L], Fottner J

For further information in this module, please click
campus.tum.de or here.

Module Description

MW2129: Ergonomics

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a written exam (90 minutes). Students should remember the content of the course and apply calculation methods, they should analyze and evaluate ergonomic issues and given case studies.
Participation in the lecture and exercise as well as self-study is recommended.
Permitted tools: calculator

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Arbeitswissenschaft/Ergonomics is designed as an entry-level and summary module.

Content:
In addition to an overview of the basics of ergonomics models of human perception, information processing and motor skills are presented. Basic communication models are discussed and their significance for the design of human-machine interaction, using examples from the different parts of ergonomics. Based on the principles of measurement theory approaches and tools for the evaluation of human-machine interaction and also the measurement of quality and performance of human labor are discussed.
Lecture chapters: Fundamentals and fields of work, tasks of ergonomists, History and Sociological Aspects, Demographics, Future Work, Industry 4.0, anthropometry, physiology, cognition - perception - information processing, interaction and communication, measurement & evaluation, work organizations

Intended Learning Outcomes:
Students are able to:
¿ represent fundamentals of ergonomics,
¿ analyse stress and strain of the people according to ergonomic guidelines,
¿ apply basic principles of anthropometry.
¿ In addition, students understand and apply the processes of perception, human information processing and implementation,
¿ analyze communication processes in work systems,
¿ apply measurement and evaluation methods,
¿ apply individual aspects in other areas of work.

Teaching and Learning Methods:
The course is based on a presentation with processing of case studies and practical applications.
In the exercise, the content of the lecture are deepened and illustrates the practical relevance of the content is illustrated by means of examples. The exercise is designed as a tutorial. The literature cited is recommended.

During the excursion the theoretical contents will be examined in practice.

Media:
Lecture: Power point presentation, Literature
Exercise: Exercise Documents, field trip

Reading List:
Schlick et al. (2010): Arbeitswissenschaft. Berlin: Springer. Schmidtke, Heinz (1993): Ergonomie. 3., neubearb. und erw. Aufl. München: Hanser.
Schmidtke, Heinz (2002): Handbuch der Ergonomie. HdE, mit ergonomischen Konstruktionsrichtlinien und Methoden. 2., überarb. und erw. Aufl. München: Hanser.
Wickens, Christopher D.; Gordon, Sallie E.; Liu, Yili (1998): An introduction to human factors engineering. New York: Longman.
Wickens, Christopher D.; Hollands, Justin G. (2000): Engineering psychology and human performance. 3. ed. Upper Saddle River, NJ: Prentice-Hall.
Goldstein, E.B. (2009): Sensation and perception. Belmont, CA, Wadsworth Cengage Learning.

Further and specific literature regarding the individual topics will be mentioned in the lecture notes.

Responsible for Module:
Bengler, Klaus; Prof. Dr. phil.

Courses (Type of course, Weekly hours per semester), Instructor:
Arbeitswissenschaft / Ergonomics Exercise (exercise, 1 SWS)
Knott V [L], Albers D, Knott V

Excursion Ergonomics (field trip, ,5 SWS)
Knott V [L], Albers D, Knott V

Arbeitswissenschaft / Ergonomics Exercise Teacher Education (exercise, 1 SWS)
Knott V [L], Albers D, Knott V

Ergonomics (lecture, 2 SWS)
Knott V [L], Bengler K, Knott V, Albers D, Fleischer M

For further information in this module, please click
campus.tum.de or here.

Specialization in Technology: Informatics (minor)

Module Description

IN0001: Introduction to Informatics 1

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Type of Assessment: exam (120 minutes)

The exam takes the form of 120 minutes written test. Questions allow to assess acquaintance with concepts of Informatics and programming, small programming tasks assess the ability to conceive appropriate algorithmic solutions and realize concurrent applications.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Participants should attend IN0002 "Fundamentals of Programming (Exercises & Laboratory)" at the same time.

Content:
The module IN0001 is concerned with topics such as:
- Introduction
  ++ Basic notions: Problem - algorithm - program
  ++ Imperative programming constructs
- Syntax and semantics
  ++ Syntax of programming languages: regular expressions and contextfree grammers
  ++ Semantics of programs: control-flow graphs
- Basic data structures I
  ++ Numbers, strings, arrays
  ++ Insertion sort
- Recursion
  ++ Binary search
  ++ Patterns of recursion
- Basic data structures II
  ++ Objects, classes, methods
  ++ Lists, stacks, queues
- Object-oriented programming
  ++ Inheritance
  ++ Abstract classes and interfaces
  ++ Polymorphism
- Programming in the large (perspectives)
- Concurrency and Threads

Intended Learning Outcomes:
Upon successful completion of the module participants understand the essential concepts of computer science on a fundamental, practice-oriented, but scientific level.
Concepts of this kind are for example: Algorithms, syntax and semantics, as well as efficiency in terms of memory consumption or time.
Participants are then able to solve well-posed algorithmic problems and to implement basic distributed and concurrent applications in Java or a similar object-oriented language. They understand the underlying concepts and models and are therefore able to acquire skills in other imperative and object-oriented programming languages on their own.

Teaching and Learning Methods:
lecture, combined with experimental assessment of examples at the computer and evaluation of further readings

Media:
slide show, blackboard, online programming experiments, animations, lecture recording

Reading List:
Heinisch, Müller-Hofmann, Goll: Java als erste Programmiersprache, Teubner, 2007
Deitel, Harvey / Deitel, Paul: How to program Java Prentice-Hall, 2002
Flanagan, David: Java in a Nutshell O'Reilly, 2002
Bishop, Judith: Java gently Prentice-Hall, 2001
Eckel, Bruce: Thinking in Java Prentice-Hall, 2002

Responsible for Module:
Seidl, Helmut; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Introduction to Informatics 1 (IN0001) (lecture, 4 SWS)
Seidl H, Erhard J, Hagerer G, Kynast E

For further information in this module, please click
campus.tum.de or here.

Module Description

IN0002: Fundamentals of Programming (Exercises & Laboratory)

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Type of Assessment: exercise work

On 7 to 14 exercise sheets questions or programming tasks will be posed, which have to be solved and handed in by the participants in written or electronic form. By that paticipants approve that they are able to do programming in the small by means of an object-oriented programming language such as Java and that they have understood fundamental concepts of Informatics and are able to apply these in order to provide original solutions or programs. In order to identify the individual contributions of the participants they must be able to defend their solutions interactively. Before the beginning of classes, it shall be announced how the single exercise sheets contribute to the final grade.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Participants should attend IN0001 "Introduction to Informatics 1" at the same time.

Content:
Accompanying the module IN0001, assignments may excercise and apply for problem solving concepts, such as:
- basic data structures
- recursion
- objects, classes and methods
- lists, queues, and trees
- advanced concepts of object-oriented programming
- concurrency

Intended Learning Outcomes:
After successful completion of the module, participants are acquainted with the programming language Java or a similar object-oriented programming languae and master programming in the small. They are able to realize programs on their own and to apply the fundamental concepts of Informatics as taught in module IN0001, on a basic practical but scientific level.

Teaching and Learning Methods:
Approximately a quarter of the module consists of the processing of exercises for the accompanying module IN0001. These exercises deepen the understanding of fundamental concepts of computer science.
During the remainder of the time, the participants develop small sample applications under guidance to develop their programming skills in an object-oriented programming language.

Media:
Beamer, slides, whitebord, software development environment

Reading List:
See modul IN0001

Responsible for Module:
Seidl, Helmut; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Fundamentals of Programming (Exercises & Laboratory) (IN0002), Thu (practical training, 4 SWS)
Seidl H [L], Erhard J, Hagerer G, Kynast E

For further information in this module, please click
campus.tum.de or here.

Module Description

IN0004: Introduction to Computer Organization and Technology - Computer Architecture

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
8	240	150	90

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination will be conducted in written form as part of a 120 minute exam. Here, examples from different areas of machine oriented programming in Assembler, micro-programming, circuit design and hardware description languages will be used to assess the capability of the students to master such concepts of computer architectures. Answers to short questions about basic concepts in computer architecture must show that the candidates mastered these concepts. Support material is provided during the examination, no additional help is allowed.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
none

Content:
- Computer systems: basic architecture and organization: Von-Neumann-Computer, machine-instruction cycle, hardware-software interface
- The Instruction Set Architecture (ISA): functionality and machineoriented Assembler programming
- Micro-programmed implementation of machine instructions
- Circuits, sequential circuits, circuit design with a formal language using the example of VHDL
- Introduction to computer architecture: microprocessor architectures and systems, parallel and distributed systems, memory systems, I/O

Intended Learning Outcomes:
After attending this module students are able to understand computer systems as layered abstract machines. They get a first impression of the area of computer architectures and possess the following abilities:
They have learned to apply the main concepts of machine-oriented programming, microprogramming and circuit design. They understand the machine instruction cycles based on the underlying hardware at the register transfer level and they are able to classify computer architectures. The understand the basics of modern computer architecture.

Teaching and Learning Methods:
Using slide decks with animations, the lecture explains the basic concepts of computer architecture. This is supported by a concurrent series of central exercise sessions as well as small tutor groups, which explain the application of the material presented in the class. Homework allows the students to self-study the material. Solutions are then discussed both in the central exercise class as well as the smaller tutor groups. The ability to present their own solution as part of the tutor groups further aids in the understanding of the material and supports

the
students¿ ability to communicate.

Media:
Slides of lectures, exercise sheets with assignments, collections of assignments, other working material.

Reading List:
- Andrew S. Tanenbaum, Todd Austin: Rechnerarchitektur: Von der digitalen Logik zum Parallelrechner
- David A. Patterson, John L. Hennessy, Computer Organization and Design: The Hardware/Software Interface
- Intel386 TM DX MICROPROCESSOR 32-BIT CHMOS MICROPROCESSOR WITH INTEGRATED MEMORY MANAGEMENT
- Beschreibung der mikroprogrammierbaren Maschine

Responsible for Module:
Schulz, Martin; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Introduction to Computer Architecture (IN0004) (lecture, 4 SWS)
Schulz M (Huseynli F, Schreiber M)

Introduction to Computer Organization and Technology - Computer Architecture, Exercise Session - Groups Monday, Tuesday, Wednesday(IN0004) (exercise, 2 SWS)
Schulz M [L], Huseynli F, Schreiber M

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

IN0006: Introduction to Software Engineering

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German/English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	105	75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Type of assessment: written exam
The exam takes the form of a 90 minutes written test. The examination consists of describing the main concepts and methods of each phase of the software engineering process. The students have to apply their knowledge to solve small problems. By means of modelling problems, the students have to show their ability to adequately analyze and evaluate given requirements.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
IN0002 Fundamentals of Programming (Exercises & Laboratory)

Content:
Software engineering is the the establishment and systematic use of engineering principles, methods, and tools for the division of work, the development and application of extensive, complex software systems. It deals with the production and development of software, the organization and modelling of data structures and objects, and the operation of software systems. Topics of the lecture include, among others:
- Modeling with UML
- Process models in software development (linear, iterative, agile)
- Requirements elicitation and analysis (functional model, dynamic model, and object model)
- System design (specification, software architecture, architectural patterns, and design goals)
- Object design and implementation (reuse, design patterns, and interface specification)
- Testing (component test, integration test, and system test)
- Configuration management, build management, and release management
- Software maintenance and evolution
- Project organization and communication

Intended Learning Outcomes:
After successful completion of this module, students are familiar with the basic concepts and methods of the different phases of a project, e.g. modeling the problem, reuse of classes and components, and delivery of the software. They have the ability to select and apply suitable concepts and methods for concrete problems.

The students know the most important software engineering terms and workflows and are able to analyze and evaluate given problems. In addition, students can solve concrete problems in software engineering, e.g. with the help of design patterns.

Teaching and Learning Methods:
By means of a slide presentation with animations, the interactive lecture introduces the basic concepts and methods of software engineering and explains them using examples. Small exercises, e.g. quizzes, modelling, and programming tasks, with individual feedback help students to identify whether they have understood the basic concepts and methods.
Accompanying tutorials deepen the understanding of the concepts explained in the lecture by means of suitable group exercises and show the application of the different methods with the help of manageable problems in the different phases of software engineering. Homework enables students to deepen their knowledge in self-study. The presentation of the own solution in the accompanying tutorials improves communication skills, which are essential in software engineering. Individual feedback on homework allows students to measure learning progress and improve their skills.

Media:
Lecture with digital slides, livestream, online exercises (programming, modeling, quiz) with individual feedback, discussion forum and communication platform for the exchange between instructors, tutors, and students

Reading List:
B. Bruegge, A. Dutoit: Object-Oriented Software Engineering: Using UML, Design Patterns and Java, 3rd Edition, Pearson Education, 2010
I. Sommerville, Software Engineering, 9th edition, Addison Wesley, 2010

Responsible for Module:
Matthes, Florian; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Introduction to Software Engineering (IN0006) (lecture, 3 SWS)
Brügge B [L], Krusche S, von Frankenberg und Ludwigsdorff N, Bernius J

For further information in this module, please click
campus.tum.de or here.

Module Description

IN0008: Fundamentals of Databases

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	105	75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The academic assessment will be done by a 90 minutes written exam. Assignments checking knowledge verify the familiarity with the main concepts of relational database systems. Transfer assignments and small scenarios check the ability to apply and evaluate these concepts systematically and in a qualified manner.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
IN0015 Discrete Structures, IN0001 Introduction to Informatics 1

Content:
SQL, data integrity, theory of relational database design, physical data organisation (storage structures, index structures), query processing, transaction management, main features of error handling (recovery, backup) and multi-user synchronisation, security aspects (authorization), XML data modeling (optional); in the tutorial the content is practiced along concrete examples

Intended Learning Outcomes:
Students are able to apply the essential concepts of relational database systems and can use and evaluate them systematically and in a qualified manner.
The students have the expertise to systematically use a database system starting from the conceptual design to the implementation design to the physical design. They are able to formulate even complex queries in SQL and have a basic understanding of logical and physical optimization based on relational algebra. Furthermore they know how to safe-guard a database application with respect to recovery, concurrency control and authorization.

Teaching and Learning Methods:
Lecture, tutorial, problems for individual study, web interface to the data base system HyPer for actively testing SQL queries and self-study of query plans

Media:
Lecture with animated slides

Reading List:
- Alfons Kemper, André Eickler: Datenbanksysteme. Eine Einführung. 8., aktualisierte und erweiterte Auflage, Oldenbourg Verlag, 2011
- A. Kemper, M. Wimmer: Übungsbuch: Datenbanksysteme. 3. Auflage Oldenbourg Verlag, 2012
- A. Silberschatz, H. F. Korth, S. Sudarshan: Database System Concepts. Sixth Edition, McGraw-Hill, 2010

Responsible for Module:
Kemper, Alfons; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Fundamentals of Databases (IN0008) (lecture, 3 SWS)
Neumann T, Sichert M, Vogel L

Fundamentals of Databases, Exercise Session (IN0008) Groups 1-25 (exercise, 2 SWS)
Sichert M, Vogel L

For further information in this module, please click
campus.tum.de or here.

Module Description

IN0009: Basic Principles: Operating Systems and System Software

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	105	75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the 90 minutes written exam students have to show their understanding of the subjects, like resource management and the usage of systems software. They have to prove to be able to identify a given problem and find solutions within limited time.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
IN0001 Introduction to Informatics 1 and IN0004 Introduction to Computer Organization and Technology - Computer Architecture are recommended

Content:
Basic concepts: Operating systems; concurrency; parallel programming; low-level programming (processes, memory, communication, resource management; models (abstract, formal) for concurrency, e.g. petri nets; mutual exclusion, synchronization, deadlocks; compiler/linker/loader with library integration, transition to (adequate) hardware basic, machine-oriented programming and C; I/O especially as preparation for networking)

Intended Learning Outcomes:
After visiting this module, students are able to understand the basics, problems and solutions of operating systems and current developments. In addition they understand the components like process and memory management and they are able to analyze and evaluate different strategies and techniques. They learn to apply the acquired basic knowledge to new developments in the area of operating systems as well as system software.

Teaching and Learning Methods:
By means of a slide presentation, the lecture introduces the basic concepts and methods of operating systems and explains them using examples.
Accompanying tutorials deepen the understanding of the concepts explained in the lecture by means of suitable group exercises and show the application of the different methods with the help of manageable problems in the different aspects of operating system decomposition.
Additional programming exercises enable students to deepen their knowledge in self-study. Feedback and help in programming tutoring sessions allow students to measure learning progress and improve their skills.

Media:
Slides and further documents via moodle

Reading List:
A.S. Tanenbaum, H. Bos: Modern Operating Systems, 4/E (Pearson, 2015)

Responsible for Module:
Baumgarten, Uwe; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Basic Principles: Operating Systems and System Software (IN0009) (lecture, 3 SWS)
Ott J [L], Ott J

Basic Principles: Operating Systems and System Software, Exercise Session (IN0009) (exercise, 2 SWS)
Ott J [L], Uhl M, Doan T, Haus M

For further information in this module, please click
campus.tum.de or here.

Specialization in Technology: Informatics (major)

Technische Universität München

Module Description

IN0010: Introduction to Computer Networking and Distributed Systems

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	105	75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The exam takes the form of a 90 minutes written test. Comprehension questions and calculation tasks allow to assess acquaintance with the technologies and methods of computer networks and distributed systems, and the understanding obtained by implementation of protocol mechanisms. Calculation tasks also allow to assess the ability to determine the performance of selected computer networks and distributed applications.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
IN0001 Introduction to Informatics 1, IN0003 Introduction to Informatics 2 - since WiSe 2018/19 Functional Programming and Verification, IN0002 Fundamentals of Programming (Exercises & Laboratory)

Content:
- Computer networking
 ++ Overview: Computer networking and the Internet
  +++ components (router, switches, clients, server)
  +++ design (topology, routing, packets vs. virtual circuits)
  +++ layered system structure (OSI and Internet)
  +++ historical background
 ++ concepts used by multiple layers (covered within the appropriate layers):
  +++ Addressing
  +++ Error detection
  +++ Coding and modulation
  +++ Media access protocols
  +++ Flow control
  +++ Connection management
  +++ Packet vs. virtual circuit switching
 ++ Layers:
  +++ Application layer: application protocols and applications
   ++++ Tasks and interface
   ++++ Examples: HTTP, DNS, SMTP (Mail), Peer-to-Peer protocols
  +++ Transport layer
   ++++ Tasks and interface
   ++++ Examples: TCP and UDP
  +++ Network layer
   ++++ Tasks and interface
   ++++ Routing: link state vs. distance vector protocols

++++ Addressing: IP Addresses
++++ Examples: IP, Routing in the Internet
+++ Link layer
++++ Tasks and interface
++++ Examples: Ethernet, Wireless LAN
+++ Physical layer
++++ Tasks and interface
++++ Examples
- Distributed systems:
++ Middleware, e.g. RPC
++ Web Services
- General tasks:
++ Network management
++ IT security
+++ Basics of cryptography
+++ Authentication, privacy, integrity
+++ Protocols with security mechanisms, e.g.: IPsec, PGP, Kerberos, SSL, SSH, ...
+++ Firewalls, intrusion detection

Content of the Exercises:
The exercises cover comprehension questions and calculation tasks and target determination of performance of protocols and mechanisms of specific layers (Physical Layer, Data Link Layer, Network Layer, Transport Layer). Programming exercises address implementation of specific protocol mechanisms.

Intended Learning Outcomes:
After successful completion of the module, participants understand the key concepts of technologies and methods of computer networks and distributed systems and are able to use key layered network architecture protocols to explain what protocol mechanisms are used in each layer and how they work. They understand the architecture of distributed applications like the World Wide Web based on Internet protocols, and the architecture of computer networks. Participants can determine the performance of selected networks and distributed applications, and can implement specific protocol mechanisms.

Teaching and Learning Methods:
The interactive lecture with slide presentations, animations, demonstrations and life programming presents the basic knowledge of computer networks and distributed systems and explains them using examples. Quizzes help students to recognize whether they have understood the basic concepts and essential contexts. Homework enables students to deepen their knowledge in self-study. Accompanying tutor exercises deepen the understanding of the contents of the lecture by means of suitable tasks and show the application of the various methods on the basis of manageable problems. The presentation of the own solution in the accompanying tutorial improves the communication skills and allows to compare the own learning progress with that of other students. Programming tasks allow computer-aided deepening and application of conceptual knowledge to practical problems.

Media:
Lecture slides, exercise sheets, demonstrations

Reading List:
Literature is specified at the web presence of the course and in the lecture slides.

Standard publications are among others:
1. James F. Kurose, Keith W. Ross
Computernetzwerke
Pearson Studium; 5. aktualisierte Auflage, 2012
2. Andrew S. Tanenbaum / Prof. David J. Wetherall
Computernetzwerke
Pearson Studium, 5. aktualisierte Auflage, 2012

Responsible for Module:
Carle, Georg; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Introduction to Computer Networking and Distributed Systems (IN0010) (lecture, 3 SWS)
Carle G [L], Carle G, Günther S, Stubbe H

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

IN2031: Application and Implementation of Database Systems

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor/Master	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	105	75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The academic assessment will be done by a written exam of 90 minutes. Assignments checking knowledge verify the familiarity with components of modern database systems; programming assignments verify the ability to implement and critically evaluate advanced algorithms and data structures of the database components; small scenarios with defined architectures and applications have to be set up with the methods learnt which verifies the ability to develop precise partial solutions.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
IN0008 Fundamentals of Databases, IN0007 Fundamentals of Algorithms and Data Structures

Content:
- Error Handling
- Concurrency Control
- Security and Privacy
- Object Oriented und Object Relational Database Concepts
- Deductive Databases
- Distributed Databases
- Business Intelligence: Data Warehousing, Data Mining
- Main Memory Database Systems
- XML and Database Systems
- Database Concepts in the Context of Big Data Applications
- Performance Evaluation

Intended Learning Outcomes:
Students command the components of modern database systems in detail, they know how to implement and evaluate the underlying algorithms and data structures, and are able to develop them further under different constraints.

Teaching and Learning Methods:
Lecture, tutorial, problems for individual study

Media:
Lecture with animated slides

Reading List:
- Alfons Kemper, André Eickler: Datenbanksysteme. Eine Einführung. 10., aktualisierte und erweiterte Auflage, Oldenbourg Verlag, 2015
- A. Kemper, M. Wimmer: Übungsbuch: Datenbanksysteme. 3. Auflage Oldenbourg Verlag, 2012
- A. Silberschatz, H. F. Korth, S. Sudarshan: Database System Concepts. Sixth Edition, McGraw-Hill, 2010
- T. Härder, E. Rahm: Datenbanksysteme - Konzepte und Techniken der Implementierung. 2. Auflage, Springer Verlag, 2001
- J. Gray, A. Reuter: Transaction Processing: Concepts and Techniques. Morgan Kaufmann, 1993

Responsible for Module:
Kemper, Alfons; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Application and Implementation of Database Systems (IN2031) (lecture, 3 SWS)
Kemper A

Application and Implementation of Database Systems, Exercise Session (IN2031) (exercise, 2 SWS)
Kemper A [L], Bandle M, Schüle M

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

IN2040: Virtual Machines

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor/Master	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	105	75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The assessment is by means of a written exam of 90 minutes. Individual assignments ask to apply the learnt translation schemes to small example programs. By that, the exam assesses how well the student is acquainted with various programming constructs and whether she or he is able to translate these into machine code. Further assignments reflect on the concept of virtual machines itself by proposing extra language concepts for which translation schemes should be provided. The successful completion of homework asignments may contribute to the grade as a bonus. The exact details for this are announced timely at the begin of the lecture.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
At least rudimentary knowledge of different programming languages.

Content:
While trying to produce code for a programming language like Prolog, one quickly realizes that one would like to use certain instructions during the translation which are not already available on concrete machines. On the other hand, instruction sets of modern computers are changing so quickly that it doesn't seem useful for the compiler to depend on some arbitrarily chosen instructions. Such a dependance would mean that in a few years one would feel obliged to rewrite the compiler anew.

With the implementation of the first Pascal compilers, one already arrived at the idea of first generating code for a slightly idealized machine, each of whose instructions then only need to be implemented on different target machines. Translation of modern programming languages like Prolog, Haskell or Java are also based on this principle. On one hand this facilitates portability of the compiler. On the other hand this also simplifies the translation itself since one can choose a suitable instruction set according to the programming language to be translated. In particular, we consider:
- the translation of C;
- the translation of a functional language;
- the translation of Prolog;
- the translation of a concurrent dialect of C.

Intended Learning Outcomes:
Participants are acquainted with virtual machines for imperative, functional, logical and object-oriented programming languages. They know the principles by which various programming language concepts are translated into sequences of machine code. For sections of programs, they are able to generate code of some virtual machine, and they are able to apply the learnt principles to provide new translation schemes for given language constructs on their own.

Teaching and Learning Methods:
By means of a presentation, either by slides or whiteboard, the lecture presents schemata for the translation of various language constructs and illustrates these by means of small examples. Accompanying assignments for individual study deepen the understanding of the concepts explained in the lecture, and train students to apply the learnt schemata for the translation and to develop new schemata for selected language constructs.

Media:
Slide show, blackboard, possibly online programming and/or animations

Reading List:
Seidl, wilhelm: Compiler Design. Virtual Machines. Springer, 2010

Responsible for Module:
Seidl, Helmut; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Virtual Machines (IN2040) (lecture with integrated exercises, 5 SWS)
Izycheva A, Petter M, Seidl H, Vogler R

For further information in this module, please click
campus.tum.de or here.

Module Description

IN2062: Techniques in Artificial Intelligence

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor/Master	German/English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The duration of the written exam is 90 minutes. In the written exam students should prove to be able to identify a given problem and find solutions within limited time.
A collection of formulas and tables required to solve the given problems is provided. Students are only allowed to bring pens and a calculator (non-progammable). The questions require to solve problems mathematically and to answer questions in natural language.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
IN0007 Fundamentals of Algorithms and Data Structures, IN0015 Discrete Struktures

Content:
The course gives an overview of application areas and techniques in Artificial Intelligence. The course introduces the principles and techniques of Artificial Intelligence based on the textbook of Russell and Norvig (see below). The course covers the following topics:
- design principles and specification mechanisms for rational agents;
- problem solving using heuristic search: heuristic search techniques, optimizing search;
- problem solving using knowledge-based techniques: logic and inference techniques; reasoning about space and time; representation of ontologies; representation and reasoniong in the common sense world;
- problem solving using uncertain knowledge and information: basic concepts of probability and decision theory; Bayesian Networks; planning with Markov decision problems;
- action planning: automatic generation of partially ordered action plans; planning and execution;
- machine learning: learning decision trees; inductive learning; probably approximately correct learning; reinforcement learning.

Intended Learning Outcomes:
The participants will attain capabilities to solve complex problems using fundamental methods and techniques of artificial intelligence. The techniques include agent-based problem solving, problem solving through (heuristic) search, the representation of knowledge, reasoning mechanisms, problem solving under uncertainty, action planning and machine learning.
Examples are search algorithms, methods of logical inference, as well as computation of state probabilities of Bayesian networks and hidden Markov models.

Teaching and Learning Methods:
The module consists of a lecture and exercise classes. The content of the lecture is presented via slides, which are

completed during the lecture using the blackboard. Also, the learning progress is checked during the lecture using the survey tool Tweedback. Students are encouraged to additionally study the relevant literature. In the exercise classes, the learned content is applied to practical examples to consolidate the content of the lecture.

Media:
Slides, assignment sheets

Reading List:
Stuart Russel and Peter Norvig: Artificial Intelligence - A Modern Approach, Prentice Hall

Responsible for Module:
Althoff, Matthias; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Techniques in Artificial Intelligence (IN2062) (lecture with integrated exercises, 4 SWS)
Althoff M, Klischat M, Kochdumper N, Koschi M, Maierhofer S, Rettinger A, Wang X

For further information in this module, please click
campus.tum.de or here.

Specialization in Technology: Chemistry (minor)

Required Modules

Technische Universität München

Module Description

CH1090: Introduction to Organic Chemistry

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Eine Prüfungsleistung wird in Form einer Klausur (90 Minuten) erbracht. In dieser soll nachgewiesen werden, dass in begrenzter Zeit und ohne Hilfsmittel ein Problem erkannt wird und Wege zu einer Lösung gefunden werden können. Dabei sollen die Studierenden zeigen, dass sie die organische Chemie wichtiger Verbindungen aus Natur und Technik bewerten können. Sie verstehen Aufbauprinzipien und Eigenschaften der grundlegenden Naturstoffklassen. Die Studierenden sind vertraut mit den grundlegenden Reaktionsweisen organischer Verbindungen und können diese wiedergeben. Die Prüfungsfragen gehen über den gesamten Modulstoff. Die Antworten erfordern teils eigene Berechnungen und Formulierungen teils Ankreuzen von vorgegebenen Mehrfachantworten.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Lectures in Basic and inorganic chemistry.

Content:
Introduction:
What is Organic Chemistry ? Structural units, alkyl chains, functional groups, structural principles, isomerism, geometry, chirality

Hydrocarbons:
Alkanes, cycloalkanes, alkenes, alkynes, aromaticity, aromatics

Oxygen compounds :
Polar bond, alcohols, ethers, aldehydes, ketones, carboxylic acids, esters

Petroleum, petrochemicals, fuels, triglycerides:
Petroleum and petrochemicals, fats, oils, triglycerides, fatty acids, modern fuels, bioethanol, biodiesel, synthetic fuels

Water and organic molecules:
The structure of water, entropy, hydrophilicity, hydrophobicity, polar and non-polar solvents, surfactants, fat hydrolysis, phospholipids

Organic dyes and pigments:
Creation and perception of light and color, chromophores, natural organic dyes indigo and madder, triphenylmethane-, tar-, azodyes, phthalocyanines, modern high-performance pigments, optical brighteners

Carbohydrates:
Glucose and isomeric sugar, hemiacetal formation and pyranoses, mono-, di-, and polysaccharides, starch, cellulose

Proteins:
Amino acids and peptide bond, peptides, proteins, primary, secondary, tertiary structure, the key - lock principle, fibrous proteins: keratins, collagen

Plastics:
Thermoplastics, elastomers and thermosets, polymer types, polymerization and the polymerisates, polycondensation and polycondensates , polyaddition and polyadducts

In-depth knowledge:
Industrial organic chemistry: pharmaceuticals, evaluation of chemical reactions: yield and atom economy, terpenes, DNA and RNA

Intended Learning Outcomes:
After participating in the module, the students are able to evaluate the organic chemistry of important compounds in nature and technology. They understand structural principles and properties of the basic classes of natural products. Students are familiar with the basic modes of reaction of organic compounds.

Teaching and Learning Methods:
The module consists of a lecture with accompanying exercises. The contents are taught in lecture and through presentations. Students should be encouraged to substantive discussion of the issues and to study advanced literature. Exercises are given in correlation to the lecture progress and will be discussed centrally after a given processing time.

Media:
Script, presentation, exercise sheets.

Reading List:
H. Beyer, W. Francke, W. Walter, "Lehrbuch der Organischen Chemie", lecture script

Responsible for Module:
Fontain, Eric; PD Dr. rer. nat. habil.

Courses (Type of course, Weekly hours per semester), Instructor:
English title will be supplied (exercise, 1 SWS)
Fontain E

English title will be supplied (lecture, 3 SWS)
Fontain E

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

CH1091: Basic Principles of Physical Chemistry 1

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination is done in the form of a written exam (90 minutes). In this, it should be demonstrated that in limited time and without aids a problem is identified and ways to a solution can be found. To demonstrate the learning outcomes achieved, students should recognize the statistical nature of thermodynamics and kinetics and remember the Gibbsian formalism. The students understand the role of state functions and their function in thermochemistry, equilibrium and kinetics and can explain this. Furthermore, the students show that they can apply the solved equations to concrete problems of thermodynamics and kinetics. They know standard phenomena of thermodynamics and kinetics and can formally analyze them. The exam questions go over the entire module material. The answers partly require own calculations and phrasing, partly ticking of predetermined multiple answers.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Introduction to General chemistry

Content:
1) Equations of state for ideal and real gases (intermolecular interactions, van der Waals equation, and virial developement) .
2) Kinetic theory of gases , specific heat, translational, rotational and vibrational degrees of freedom, Boltzmann and Maxwell distribution (including basic statistical considerations).
3) 1 Law: Internal energy and enthalpy as a state function, isothermal and adiabatic processes, Joule-Thomson effect, Thermochemistry: set of Hess, Kirchhoff's sentence, Haber-Born cycle.
4) 2 Law: reversible and irreversible processes, Carnot cycle, entropy, 3. Law , phase transition and Trouton'sche rule, efficiency, heat pump, free energy / free enthalpy (maximum work).
5) Equilibrium: partial molar quantities, chemical potential, Herny's and Raoult law, law of mass action, thermodynamic and other equilibrium constants, pressure dependence, Le Chatelier, van't Hoff equation, activity.
6) Formal kinetics , first and second order, parallel and consecutive reactions, pseudo first order, enzyme kinetics, relaxation to equilibrium, steady state.
7) Theoretical treatment of kinetics: Arrhenius law, theory of the transition state.

Intended Learning Outcomes:
After attending this module, students should be able to: 1) recognize the statistical nature of thermodynamics and kinetics, and to remember the Gibbs formalism. 2) understand and explain the importance of state functions and its function in the thermochemistry , the equilibrium and kinetics a. 3) apply and solve the developed equations to concrete problems of thermodynamics and kinetics. 4) analyze formally standard phenomena of thermodynamics and kinetics.

Teaching and Learning Methods:
The module consists of a lecture (3 SWS) and an accompanying exercise (1 SWS). The contents of the course will be taught in lecture and through presentations and animation, whereby the relationship between formal tool, microscopic theorie and diversity is explained. Practice sheets containing specific Problems are ditributed weekly for self study. In the practice sessions the self found solutions are discussed and the tasks are solved and commented afterwards. Detailed solutions can be found on the internet and include: 1) a sketch of the solution approach, 2) a complete solution with all steps of calculation and references to typical failures, 3) advanced information material to stimulate self-study.

Media:
Presentation on blackboard and projector, script

Reading List:
P.W. Atkins u. J. de Paula, Physikalische Chemie, WILEY-VCH Verlag, 2006.
P.W. Atkins, C.A. Trapp,M.P. Cady, P. Marshall, C. Giunta. Arbeitsbuch Physikalische Chemie, WILEY-VCH Verlag, 2007.
J. Tinocio Jr. , K. Sauer, J.C. Wang, Physical Chemistry, Prentice Hall (1995).

Responsible for Module:
Bachmann, Annett; Dr. phil.

Courses (Type of course, Weekly hours per semester), Instructor:
English title will be supplied (exercise, 1 SWS)
Bachmann A

English title will be supplied (lecture, 3 SWS)
Bachmann A

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

CH6202: General an Inorganic Chemistry

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsleistung wird schriftlich, in Form einer 90-minütigen Klausur erbracht. In dieser sollen die Studierenden nachweisen, dass sie in begrenzter Zeit und ohne Hilfsmittel konkrete Fragestellungen der Allgemeinen und Anorganischen Chemie (beispielsweise pH-Wert-Berechnung oder stoffchemisches Wissen) erkennen und diese lösen können. Die Prüfungsfragen gehen über den gesamten Modulstoff. Die Antworten erfordern entweder das im Modul erlernte Wissen oder daraus abgeleitete Berechnungen.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Keine Voraussetzungen notwendig.

Content:
In diesem Modul werden die grundlegenden Begriffe der Allgemeinen Chemie (Einheiten und Stoffgrößen der Chemie) behandelt. Nachfolgend erlernen die Studierenden, nach welchen Prinzipien und Methoden chemische Reaktionen, Rechnungen und Fragestellungen zu bearbeiten sind. Hierbei behandelt das Modul beispielsweise das Aufstellen von Reaktionsgleichungen, die Berechnungen von pH-Werten, von Einwaagen, von Konzentrationen sowie die Grundlagen der Elektrochemie. Neben den allgemeinen Aspekten der Chemie steht weiterhin die Anorganische Stoffchemie im Vordergrund des Moduls. Dabei werden überwiegend die Hauptgruppenelemente des Periodensystems behandelt. Den Studierenden wird stoffspezifisch das unterschiedliche Verhalten der Elemente vermittelt (Reaktivität von Elementen und Verbindungen). Es werden von jedem Element wichtige und anwendungsrelevante Verbindungen besprochen. Hierbei wird auch auf wichtige Teilaspekte für die Studierenden des Umweltingenieurwesens näher eingegangen (z.B.: Toxizität von Verbindungen, Treibhaus- und Umweltproblematik verschiedener Stoffe, Ansätze zur verbesserten Energieeffizienz).

Intended Learning Outcomes:
Nach der Teilnahme am Modul "Allgemeine und Anorganische Chemie" sind die Studierenden in der Lage, die grundlegenden Fachbegriffe der Chemie zu nennen und die wichtigsten Einheiten und Stoffgrößen zu erkennen, zu verstehen und selber anzuwenden. Weiterhin sind die Studierenden in der Lage, chemische Reaktionsgleichungen aufzustellen und mögliche Probleme in der Reaktivität der Stoffe zu erkennen und zu benennen und zugehörige Rechnungen (pH-Wert, Konzentration oder Löslichkeit) zu lösen. Die Studierenden verstehen die Grundlagen der Elektrochemie und sind mit der Stoffchemie der Hauptgruppenelemente des Periodensystems vertraut. Die Studierenden wissen, dass Elemente unterschiedliche Eigenschaften besitzen und, in Verbindungen, unterschiedlich reagieren. Darüber hinaus sind die Studierenden nach der Teilnahme am Modul in der Lage, die Prinzipien und Methoden der Chemie, welche sich überwiegend in den analytischen Denkweisen und den angewandten Rechnungen widerspiegeln, zu verstehen und anzuwenden. Weiterhin entwickeln die

Studierenden einen analytischen Blick für aktuelle umweltpolitische Probleme (z. B. Feinstaubdiskussion, Treibhaus- und Umweltproblematik verschiedener Stoffe, Ansätze zur verbesserten Energieeffizienz).

Teaching and Learning Methods:
Das Modul besteht aus einer Vorlesung (2 SWS) mit begleitender Übung (1 SWS). Die Inhalte des Moduls werden in der Vorlesung im Vortrag und durch Präsentationen vermittelt. Hierbei werden die Studierenden über die Grundlagen der Chemie zu weiterführenden Inhalten herangeführt. Der Lernstoff wird stufenweise vermittelt, sodass die Studierenden auf dem zuvor erlerntem Wissen aufbauen können. Zur Festigung der Lernergebnisse werden in der begleitenden Übung Aufgaben bearbeitet, die zeitgleich zur inhaltlichen Auseinandersetzung mit den Themen und zum Studium weiterführender Literatur anregen sollen. Des Weiteren dienen ausgegebene Hausaufgabe zur freiwilligen Festigung des Lernstoffs, bzw. zur erweiterten Übung der Modulinhalte.

Media:
Vortrag, Präsentationen, Tafelanschrieb, Übungsaufgaben

Reading List:
Mortimer/Mu¿ller: Chemie, Das Basiswissen der Chemie, 12. Auflage, 2015 (Thieme)
Riedl/Meyer: Allgemeine und Anorganische Chemie, 11. Auflage, 2013 (de Gruyter)

Responsible for Module:
Plank, Johann Peter; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
English title will be supplied (exercise, 1 SWS)
Plank J, Theobald M

English title will be supplied (lecture, 2 SWS)
Plank J, Theobald M

For further information in this module, please click
campus.tum.de or here.

Electives

Technische Universität München

Module Description

CH0106: Biology for Chemists

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
4	120	75	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsleistung wird schriftlich in Form von einer 90-minütigen Klausur erbracht. In dieser soll nachgewiesen werden, dass in begrenzter Zeit und ohne Hilfsmittel die Lernergebnisse des Moduls (z.B. die Grundstruktur von Biomolekülen und der Zellaufbau; wichtige biochemische Vorgänge innerhalb einer Zelle; Beziehung zwischen der chemischen Struktur und der (biologisch / biochemischen) Wirkung von organischen Molekülen; Protein-Biosynthese sowie die Grundlagen der Evolution deren molekulare Grundlagen) wiedergegeben und Fragestellungen zum Inhalt des Moduls eigenständig bearbeitet werden können. Die Prüfungsfragen gehen über den gesamten Modulstoff. Die Antworten erfordern eigene Berechnungen und Formulierungen und können teilweise die Auswahl von vorgegebenen Mehrfachantworten beinhalten.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Keine

Content:
Der Inhalt des Moduls umfasst die Grundlagen der Biochemie: Chemische Grundlagen; Moleküle des Lebens (Stoffklassen: Kohlenhydrate, Lipide, Nukleinsäuren, Aminosäuren); Grundlagen von Leben; Energie; genetische Information; DNA; Genom; Replikation; Transkription; Translation; Zellaufbau (Zytologie); Zytoskelett; Zell-Zell-Interaktionen (Gewebe); Zellzyklus; Fortpflanzung; Vererbung und Evolution; chemische Evolution; Ökologie; Immunologische Grundlagen; Grundlagen der DNA-Rekombinationstechnik.

Intended Learning Outcomes:
Nach der erfolgreichen Teilnahme am Modul verstehen die Studierenden den Aufbau von organischen Verbindungen und die wichtigsten biochemischen Vorgänge innerhalb einer Zelle. Die Studierenden erinnern sich an den Aufbau von Zellen sowie an den Aufbau der für die Biochemie und organischen Chemie relevanten Stoffklassen und die chemischen funktionellen Gruppen. Die Studierenden verstehen die Beziehung zwischen der chemischen Struktur und der (biologisch/biochemischen) Wirkung von organischen Molekülen. Die Studierenden erinnern sich an die Protein-Biosynthese sowie die Grundlagen der Evolution und verstehen deren molekulare Grundlagen. Insgesamt haben die Studierenden nach der erfolgreichen Teilnahme am Modul einen Überblick über die strukturellen und funktionellen Grundzüge von Biomolekülen.

Teaching and Learning Methods:
Das Modul besteht aus der Vorlesung Biologie für Chemiker (2 SWS) und einer begleitenden Übungsveranstaltung (1 SWS). Die Inhalte der Vorlesung werden im Vortrag, Präsentationen und Tafelanschriften vermittelt. Begleitend sollen die Studierenden die behandelten Inhalte durch Durchsicht eines geeigneten Lehrbuchs weiter vertiefen. In

der Übung werden die Inhalte der Vorlesung durch die Bearbeitung eines Fragenkatalogs ebenfalls weiter vertieft.

Media:
Vortrag mittels PowerPoint, Tafelanschrift, Skriptum, Übungsaufgabensammlung, Filme

Reading List:
Als Lehrbuch begleitend zum Modul: Campell/Reece, Biologie, Pearson Education und Alberts/Johnson/Lewis/Raff/Roberts/Walter, Molekularbiologie der Zelle, Wiley VCH.

Responsible for Module:
Buchner, Johannes; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Biology for Chemists (Lecture w/ Exercise, 3 SWS)
Buchner J, Haslbeck M

For further information in this module, please click
campus.tum.de or here.

Module Description

CH0107: Analytical Chemistry

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
3	90	60	30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsleistung wird in Form einer Klausur (180 Minuten) erbracht. In dieser soll nachgewiesen werden, dass in begrenzter Zeit und ohne Hilfsmittel die verschiedenen Schritte moderner Analytik von der Probenahme bis zur Auswertung erkannt und gängige instrumentelle Analyseverfahren erinnert werden können. Die Antworten erfordern teils eigene Berechnungen und Formulierungen teils Ankreuzen von vorgegebenen Mehrfachantworten.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Grundwissen in Chemie und Physik.

Content:
Der Analytische Prozess: Probennahme, Probenvorbereitung, Detektions- und Bestimmungsverfahren, Validierung der Ergebnisse, Qualitätssicherung. Instrumentelle Analytik, u.a. AAS, OES, RFA, MS, Kopplungstechniken. Illustrative Beispiele moderner Elementanalytik.

Intended Learning Outcomes:
Nach der Teilnahme am Modul sind die Studierenden in der Lage, die einzelnen Schritte einer chemischen Analyse von Probenahme, Probenaufbereitung, Messung, Auswertung und Validierung zu erinnern und deren Eigenheiten und Wichtigkeit zu verstehen und anzuwenden. Sie können verschiedene moderne Analyseverfahren wie AAS, OES, RFA, MS und Kopplungsverfahren benennen und erklären.

Teaching and Learning Methods:
Das Modul besteht aus einer Vorlesung deren Inhalt im Vortrag und durch Präsentationen vermittelt wird. Studierende werden zur inhaltlichen Auseindersetzung mit der Thematik und zum Studium der Literatur angeregt.

Media:
Bücher, Online-Skript

Reading List:
Skoog, Douglas A., Holler, F. James, Crouch, Stanley R. Niessner, R. (Hrsg.), Instrumentelle Analytik Grundlagen - Geräte   Anwendungen. Springer 2013, 6. Auflage.

Harris, Daniel C., Werner, Gerhard, Werner, Tobias (Hrsg.), Lehrbuch der Quantitativen Analyse. Springer 2014, 8. Auflage.

Responsible for Module:
Schuster, Michael; Prof. Dr. phil. nat.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click
campus.tum.de or here.

Module Description

CH0867: Food Chemistry I

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	150	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Modulprüfung besteht aus einer Klausur, in der die Studie-renden ohne die Verwendung von Hilfsmitteln ein vertieftes Verständnis der Grundlagen der Lebensmittelchemie an Hand der chemischen Strukturen und Reaktionsmechanismen der Hauptinhaltsstoffe von Lebensmitteln aufzeigen sollen. Die Beantwortung der Fragen erfordert eigene Formulierungen, das Anfertigen von Skizzen und das Erstellen von Reaktionsglei-chungen bzw. die Darstellung von Reaktionsmechanismen.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Keine

Content:
Die chemischen und analytischen Grundlagen der Hauptin-haltsstoffe von Lebensmitteln werden vermittelt.

Im Einzelnen werden folgende Themen behandelt:

-Aminosäuren, Peptide, Proteine (Aufbau und Struktur, Re-aktivität, Strecker-Reaktion, Analytik), sowie Enzyme (Cofaktoren, Cosubstrate, prosthetische Gruppen, Kinetik, enzymatische Analyse)
-Lipide (Aufbau und Struktur, Eigenschaften, Reaktivität, Lipidperoxidation, technologische Aspekte)
-Kohlenhydrate (Nomenklatur, Aufbau und Struktur, Reaktivität, Maillard-Reaktion, Analytik, Polysaccharide)

Intended Learning Outcomes:
Nach der Teilnahme an den Modulveranstaltungen sind die Studierenden in der Lage, die Hauptbestandteile von Lebens-mitteln detailliert chemisch zu beschreiben sowie die Analytik der genannten Stoffe zu erklären. Sie können mögliche Reakti-onen bei der Lagerung, Verarbeitung und Zubereitung von Le-bensmitteln darstellen und verstehen die Auswirkungen dieser Reaktionen auf die Qualität und Haltbarkeit von Lebensmitteln.

Teaching and Learning Methods:
Die Inhalte der Vorlesungen werden im Vortrag und durch Prä-sentationen vermittelt. Studierende sollen zum Studium der Literatur und der inhaltlichen Auseinandersetzung mit den The-men angeregt werden.
In der Übung werden Übungsaufgaben zu Themen aus der Vorlesung bearbeitet, Lösungswege diskutiert und das Formu-lieren von treffenden Antworten geübt.

Media:
Tafelanschrieb, downloadbare Präsentationen und Übungsauf-gaben

Reading List:
-H.-D. Belitz, W. Grosch, P. Schieberle: ¿Lehrbuch der Le-bensmittelchemie¿¿, 6.Auflage, Springer Verlag 2007; ISBN: 3540732012

Responsible for Module:
Schieberle, Peter; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

CH0999: Chemistry Software and Databases for TUM-BWL

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
3	90	60	30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Überprüfung der Lernergebnisse erfolgt mittels Klausur (60 Minuten). Hierbei sollen die Studierenden zeigen, dass sie chemische Datenbanken verwenden und insbesondere eine (Sub-) Strukturformelsuche anwenden können. Die Studierenden verstehen, wie die einzelnen Datenbanken aufgebaut sind und analysieren, welche Datenbank für welche Fragestellung am besten geeignet ist. Sie verstehen die Grundprinzipien des Molecular Modeling und sie können die Suche nach einer Strukturformel mit minimaler Gesamtenergie anwenden. Die Fragen der Klausur beinhalten eigene Formulierungen und das zeichnen von Stukturformeln. Es sind keine Hilfsmittel erlaubt.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Keine

Content:
Moleküle am Computer (ViewerLite), Molekülstrukturen im Internet (CSD, PDB), Protein Services im Internet (PSBSum, SCOP, PROSITE), Literatur Online (EZB, CAS, SCIFinder, Reaxys, PubMed), Einfaches Molecular Modeling (Molecular Mechanics mit HyperChem).

Intended Learning Outcomes:
Nach Bestehen des Moduls ist der Studierende in der Lage, chemische Datenbanken zu verwenden und insbesondere eine (Sub-) Strukturformelsuche anzuwenden. Der Studierende versteht, wie die einzelnen Datenbanken aufgebaut sind und kann analysieren, welche Datenbank für welche Fragestellung am besten geeignet ist. Er versteht die Grundprinzipien des Molecular Modeling und kann die Suche nach einer Strukturformel mit minimaler Gesamtenergie anwenden.

Teaching and Learning Methods:
Das Modul besteht aus einer Vorlesung und einer Übung. In der ersten Semesterhälfte erfolgt das Behandeln der theoretischen Modulinhalte mittels Vorlesung, danach die Festigung von gelerntem Wissen in der Übung als Blockkurs (1-2 Nachmittage).
Vorlesungen erfolgen als Präsentationen mittels Powerpoint zur anschaulichen Darstellung der Modulinhalte, das Skript ist für die Studierenden verfügbar (Downloadmöglichkeit für Vorlesungsmaterial). In der Übung wird mittels "Molecular Modelling"-Program und dem Versuchsskript erlerntes Wissen angewandt, gefestigt und eingeübt.

Media:
Powerpoint, Skript, Molecular Modelling-Program, Versuchsskript. Literaturstudium.

Reading List:
Geeignete Literatur wird vom Dozenten bekannt gegeben.

Responsible for Module:
Fontain, Eric; PD Dr. rer. nat. habil.

Courses (Type of course, Weekly hours per semester), Instructor:
Chemistry Software and Databases for TUM-BWL (Lecture w/ Exercise, 2 SWS)
Fontain E

For further information in this module, please click
campus.tum.de or here.

Module Description

CH1123: Chemical Engineering for TUM-BWL

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In dem Modul erfolgt die Überprüfung der Lernergebnisse über eine schriftliche Prüfung (Klausur, 120 Minuten). In dieser Prüfung sollen die Studierenden nachweisen, dass sie Reaktionskinetiken mit der Betriebsweise von Reaktoren verknüpfen und erklären können. Sie können verschiedenen Katalysen (homogen, heterogen) anhand von Beispielen aus der Produktion von Energie und Rohstoffen sowie chemischen Grundstoffen und bei der Reduktion von Emissionen beschreiben und einordnen. Die Studierenden können nachweisen, dass sie Polymere nach ihrer Herkunft und nach dem Herstellungsverfahren einordnen können. Sie können die Unterschiede zwischen idealer und realer Kinetik der radikalischen Polymerisation erklären. Sie sind in der Lage anhand vorgegebener Parameter die Produktionsleistung von verschiedenen Idealrektoren zu berechnen und können den Zusammenhang zwischen Molmasse, Molmassenverteilung und den Einfluss des Polymerisationsverfahrens auf die Molmassenverteilung wiedergeben. In der Klausur sind keine Hilfsmittel erlaubt. Es werden Aufgaben gestellt, die mittels selbst formulierter Texte beantwortet werden müssen, sowie auch Multiple Choice-Aufgaben. Darüber hinaus werden kurze Rechenaufgaben gestellt.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Grundkenntnisse in organischer Molekülchemie sowie in physikalischer und analytischer Chemie

Content:
Modulinhalte zur Technischen Chemie:
- Polymerisationsart (radikalisch, ionisch, koordinativ)
- Polymerisationsverfahren
- Reaktionsgeschwindigkeit
- Aggregatzustand von Monomeren und Polymeren
- Löslichkeit von Monomeren und Polymeren
- Wärmeentwicklung (Temperaturkontrolle)
- Viskosität
- Suspensions- und Emulsiaonspolamerisation
- Molmassenverteilung Polymerisationsgrad
- Einfluss von Verunreinigungen
- Betriebsweise: kontinuierlich oder diskontinuierlich (Wahl des Reaktors)
- Technische Möglichkeiten zum Stofftransport
- Verweilzeit (Verweilzeitverhalten)
- Wirtschaftliche Aspekte wie Energieaufwand, Kosten, Preise etc.

Modulinhalte zur Reaktionstechnik und Katalyse:

Einfache und komplexe kinetische Beschreibungen von Reaktionen, Sorption, Katalytische Reaktion als sequentielle und parallele Netzwerke, ideale Reaktoren, reale Reaktionen, Auslegung idealer Reaktoren, Wärme- und Stofftransport; Grundlegende Elemente katalysierter Reaktionen.

Intended Learning Outcomes:
Nach der Teilnahme am Modul sind die Studierenden in der Lage, Makromoleküle nach ihrer Herkunft, nach ihrer Synthese und nach ihren Eigenschaften zu beschreiben. Die Studierenden haben grundlegende Kenntnisse über Polymerisationskinetik und Polymer-Analytik. Die Studierenden haben Grundkenntnisse über Reaktorarten, Betriebsweise von Reaktoren und Polymerisationsverfahren. Weiterhin können die Studierenden die grundlegenden Elemente einfacher und komplexer Reaktionskinetik und Katalyse auf industrielle Prozesse anwenden und deren Anwendung in Reaktoren verstehen und anwenden. Dies umfasst neben homogenen Systemen, auch Reaktion, in die als Katalysatoren involviert sind (Beschreibung und Wärmeauswirkungen des Stofftransports).

Teaching and Learning Methods:
Das Modul besteht aus zwei Vorlesungen. Die Inhalte der Vorlesungen werden im Vortrag und durch Präsentationen behandelt. Studierende sollen zum Studium der Literatur und der inhaltlichen Auseinandersetzung mit den Themen angeregt werden. Im Rahmen eingeschobener Fragestunden werden konkrete Fragestellungen beantwortet und ausgesuchte Beispiele bearbeitet.

Media:
Folien, Tafelarbeit, PowerPoint, Skript

Reading List:
- Martin Brahm (Hirzel Verlag Stuttgart)
Polymerchemie Kompakt
- Wilhelm Keim (Wiley-VCH)
Kunstoffe
Synthese, Herstellungsverfahren, Apparaturen
- Hans-Georg Elias (Wiley-VCH)
Makromoleküle
Band 3; Industrielle Polymere und Synthesen
- Adolf Echte (Wiley-VCH)
Handbuch der technischen Polymerchemie
- http://www.chemgapedia.de/vsengine/topics/de/vlu/Chemie/Makromolekulare_00032Chemie/index.html
- M. Baerns, A. Behr, A. Brehm, J. Gmehling, H. Hofmann, U. Onken, A. Renken, Technische Chemie, Wiley-VCH Verlag 2006.
- G. Emig, E. Klemm, Technische Chemie, Springer 2005; O. Levenspiel, Chemical Reaction Engineering, Wiley-Verlag, NY, 1972.
- Jens Hagen, Chemische Reaktionstechnik, Eine Einführung mit Übungen, Wiley-VCH, Weinheim, 1992.

Responsible for Module:
Troll, Carsten; Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
English title will be supplied (lecture, 2 SWS)
Lercher J, Ember E

English title will be supplied (lecture, 2 SWS)
Troll C, Rieger B

For further information in this module, please click
campus.tum.de or here.

Specialization in Technology: Chemistry (major)

Module Description

CH4117: Biochemistry

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsleistung wird schriftlich in Form einer 90 minütigen Klausur erbracht. In dieser soll nachgewiesen werden, dass biochemische Stoffwechselwege für den Metabolismus von organischen Verbindungen zur Umsetzung von ATP im Detail verstanden worden sind. Ferner soll das Verständnis über den Aufbau von Biomolekülen (z.B. allgemeine Enzymklassen, Kohlenhydrate, Lipide, Protein, Nukleinsäuren) und die Eigenschaften ihrer Reaktivitäten geprüft werden. In der Klausur sind darüber hinaus Fragestellungen zur Biosynthese, Reaktivität und Stabilität Stoffwechselmetaboliten zu bearbeiten. Die Prüfungsfragen gehen über den gesamten Modulstoff. Die Antworten erfordern teils eigene Berechnungen und Formulierungen teils Ankreuzen von vorgegebenen Mehrfachantworten. Es sind keine Hilfsmittel erlaubt.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Hilfreich: "Aufbau und Struktur organischer Verbindungen"; "Reaktivität organischer Verbindungen" und "Grundlagen der Physikalischen Chemie".
Dringend empfohlen: "Biologie für Chemiker".

Content:
Generell behandelt das Modul alle grundlegenden iochemischen zellulären Stoffwechselwege. Der detaillierte Fokus liegt auf dem Verständnis der enzymatischen Grundprinzipien zur Umsetzung von Biomolekülen. Die chemischen Reaktionswege des stoffwechsels werden im Detail besprochen, wie oxidoreduktionen, Ligationen, Isomerisierungen, Transferreaktionen, Hydrolysereaktionen, Addition/Eliminierung, etc.. Die organisch-chemischen Grundlagen unterschiedlicher Funktionalitäten sowie die individuellen Co-Enzyme mit deren Besonderheiten werden im Kontext der zellulären Anforderungen molekularbiologisch diskutiert. Ein weiterer fundamentaler Aspekt ist die Bedeutung des Energiestoffwechsels hinsichtlich des Umsatzes von ATP.

Einzelne Inhalte sind:
Einleitung: Enzyme und die molekularen Aspekte ihrer Wirkung
1. Glykolyse
2. Pentosephosphatweg
3. Zitronensäurezyklus
4. Aminosäureabbau
5. Fettsäuremetabolismus
6. Nukleotidstoffwechsel
7. Atmungskette
8. Photosynthese
9. Vernetzung der unterschiedlichen Stoffwechselwege in der Zelle.

Intended Learning Outcomes:
Nach der Teilnahme am Modul "Biochemie" verstehen die Studierenden die chemischen Grundlagen der metabolischen Stoffwechselwege und deren zelluläre Vernetzung. Des Weiteren sind sie in der Lage, organisch-chemische Reaktionen für biochemische Prozesse auswerten und interpretieren zu können. Sie können tiefgreifende enzymatische Strategien verstehen und anwenden um metabolische Konversionen zu erreichen. Durch die Verknüpfung der molekularen Aspekte der Enzymfunktion und der chemischen Grundlagen von primären Stoffwechselmetaboliten können die Studierenden die Logik von biologischen Problemen nachvollziehen.

Teaching and Learning Methods:
Das Modul besteht aus einer Vorlesung (2 SWS) und einer begleitenden Übung (1 SWS). Die Inhalte der Vorlesung werden im Vortrag und Präsentationen behandelt. Begleitend sollen die Studierenden ein Lehrbuch durcharbeiten, welches zur weiteren Vertiefung auch durch weitere Literatur ergänzt werden kann. In der Übung werden die Inhalte der Vorlesung in anschaulichen Beispielen rekapituliert.
Das Modul dient der Vorbereitung der Studierenden auf die Vertiefungsfächer im Masterstudium, wie z.B. Molekulare Medizin, Bioanorganische Chemie, Biologische Chemie, Naturstoffsynthese.

Media:
Die in der Vorlesung verwendeten Medien setzen sich aus Präsentationen und Tafelaufschrieben zusammen, um den Studierenden Kenntnisse der Biochemie zu vermitteln. Die Übung dient der Anwendung und Vertiefung der erlernten Kenntnisse der Biochemie. Es wird ein Aufgabenblatt für die Übung zum Vorlesungsstoff zum Herunterladen hinterlegt. Die Musterlösung wird in einer eigenen Übungsstunde an der Tafel vorgeführt. Die Studierenden sollen zum Studium der Literatur und der inhaltlichen Auseinandersetzung mit den Themen angeregt werden.

Reading List:
Als Lehrbuch begleitend zur Vorlesung:
Berg JM, Tymoczko JL, Stryer L: Biochemie, 7. Aufl., Springer Spektrum Verlag 2012, ISBN 3827429889.
Voet D, Voet JG, Pratt CW: Lehrbuch der Biochemie, 2. Aufl., Wiley VCH, Weinheim, ISBN 9783527326679.

Responsible for Module:
Groll, Michael; Prof. Dr. rer. nat. habil.

Courses (Type of course, Weekly hours per semester), Instructor:
Biological Chemistry and Biochemistry (lecture, 2 SWS)
Groll M, Hagn F

Biochemistry, Excercises (exercise, 1 SWS)
Groll M, Hagn F

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

CH5108: Industrial Relevant Activation of Small Molecules

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	120	30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsleistung wird schriftlich in Form einer 90-minütigen Klausur erbracht. In dieser soll nachgewiesen werden, dass in begrenzter Zeit und ohne Hilfsmittel umfassendes Stoffwissen insbesondere in Themenfeldern der technisch-chemisch etablierten Aktivierung von molekularem Stickstoff zu Ammoniak, der Umsetzung von Schwefeldioxid zu Schwefelsäure, der Aktivierung von CO und CO2 sowie der effizienten Aktivierung von Alkanen - und hier insbesondere der Homologen Methan, Ethan, Propan und Butan zu wirtschaftlich wichtigen Basischemikalien abgerufen werden kann. Basiskenntnisse zur Synthesechemie, Eigenschaften und Anwendung von Zeolithkatalysatoren runden das Stoffspektrum ab. Darüber hinaus soll im Rahmen der schriftlichen Prüfung mittels Transferaufgaben und Problemlösungen gezeigt werden, dass ein Verständnis für die mechanistischen und physiko-chemischen Besonderheiten der im Modul behandelten Reaktionen erworben wurde. Alternativ zur schriftlichen Prüfung wird wahlweise ein mündlicher P&C-Modus angeboten (Präsentation eines selbstgewählten relevanten Themas und ein anschließendes Kolloquium zum Modulstoff).

Repeat Examination:
Next semester / End of Semester

(Recommended) Prerequisites:
Grundlagen der Homogenen und Heterogenen Katalyse; FUMOCAT (Fundamentals of Homogeneous Catalysis), Grundlagen der Technischen Chemie; Allgemeine und Anorganische Chemie (Bachelor Studiengang), Organische Chemie (Bachelor Studiengang).

Content:
Das Modul "Industriell relevante Aktivierung kleiner Moleküle" fokussiert sowohl auf klassische, technisch etablierte Verfahren wie die Stickstofffixierung (Haber-Bosch-Verfahren) oder Schwefelsäureherstellung als auch auf die Problematik und besonderen Herausforderungen der Inwertsetzung der Hauptbestandteile von Erdgas (hier mit besonderem Fokus auf die sehr unterschiedlichen Reaktivitäten von Methan, Ethan, Propan und Butan) oder CO und CO2 als Basisrohstoffe der modernen chemischen Industrie. Das Thema wird durch die Vermittlung von Basiskenntnissen der Zeolith basierten Katalyse abgerundet (Synthese, Eigenschaften, Anwendungsgebiete). Im Rahmen der Veranstaltung wird besonderer Wert auf die Vermittlung des Zusammenspiels etablierter Techniken und modernster, im industriellen Prozess real angewandter Katalysatorsysteme und -technologie gelegt. Fundiertes Verständnis und Kenntnisse von industriellen Verbundsystemen und chemisch-technischen Problemlösungen werden vermittelt. Die Vorlesungsinhalte werden durch die detaillierte Beschreibung aktueller, industrierelevanter Katalysatoren und deren spezifischen Eigenschaften und Einsatzgebiete bei hohem Aktualitätsgrad optimal vermittelt.

Intended Learning Outcomes:
Mit der erfolgreichen Teilnahme am Modul "Industriell relevante Aktivierung kleiner Moleküle" erwerben die Studierenden einen umfassenden Überblick sowie detaillierte Kenntnisse zu klassischen und aktuellen Beispielen

der effizienten, technisch durchgeführten Aktivierung und stofflichen Inwertsetzung von industriell relevanten Basisrohstoffen: Molekularer Stickstoff, Schwefeldioxid, Kohlenoxide, die homologen Alkane Methan, Ethan, Propan und Butan, inklusive einem Exkurs in die hierzu assoziierte Aromatenchemie. Ergänzt wird dies durch die Vermittlung von Grundlagen der Zeolith basierten Katalysechemie (Synthese, Eigenschaften und Anwendung von Zeolithkatalysatoren). Besondere Bedeutung wird dabei auf die Vermittlung der technisch / industriell wichtigen Zusammenhänge sowie auf die Zusammensetzung und Darstellung etablierter und moderner Katalysatoren sowie die Anwendung innovativer Katalysetechniken gelegt.

Teaching and Learning Methods:
Das Modul besteht aus einer Vorlesung (2 SWS) die mittels Vortrag, Präsentation unter Einbeziehung verschiedener Medien, Lernmittel und Exponaten bis hin zum selektierten Angebot fachvertiefender Industriepraktika die Inhalte auf moderne Art und Weise mit besonderem Fokus auf interaktiven Dialog zwischen Dozent und Studierenden nachhaltig vermittelt. Begleitend zur Vorlesung stehen den Studierenden via Moodle verständnisfördernde und vertiefende Übungsaufgaben zum Selbststudium zur Verfügung. Am Ende der Vorlesungszeit wird der Stoff - im Rahmen der Vorlesung - in geraffter Form rekapituliert und mittels, von den Studierenden ausgesuchten, Übungen weiterführend erläutert. Zusätzlich empfiehlt sich das Studium der angegebenen Literatur mit Bezug auf die im Vorlesungsstoff behandelten Einzelthemen sowie nicht zuletzt die Berücksichtigung der durch den Dozenten in Form von Wort und auch Tafelbild zusätzlich gegebenen Informationen.

Media:
Präsentation und detaillierte Erläuterung des Skriptums (PowerPoint), in Moodle als pdf-Dateien abrufbar; Einsatz von Video- und Audiomedien; Tafelanschrieb; intensiver Dialog mit dem Dozenten ggf. auch außerhalb der Vorlesungsstunden; Bereitstellungen von Übungen zum vertiefenden Selbststudium; Bereitstellung von Exponaten; themenvertiefendes Selbststudium auch anhand der empfohlenen Literatur. Aktive Teilnahme der Studierenden am Vorlesungsgeschehen.

Reading List:
Weissermel /Arpe Industrielle Organische Chemie, Wiley-VCH;
Büchel, Moretto, Woditsch Industrial Inorganic Chemistry, Wiley-VCH;
Baerns, Behr, Brehm, Gmehling et al. Technische Chemie, Wiley-VCH;
Beller, Renken, van Santen Catalysis, Wiley-VCH; Behr Angewandte homogene Katalyse, Wiley-VCH;
Steinborn Fundamentals of Organometallic Catalysis, Wiley-VCH;
Franck, Stadelhofer Industrial Aromatic Chemistry, Springer Verlag;
M. Bertau et al. Methanol: The Basic Chemical and Energy Feedstock of the Future, Springer;
Cornils, Herrmann, Muhler, Wong Catalysis from A to Z, Wiley-VCH; Ertl et al. Handbook of Heterogeneous Catlysis, Wiley-VCH.

Responsible for Module:
Fischer, Richard; Hon.-Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Organometallic Redox Chemistry and Activation of Small Molecules (lecture, 2 SWS)
Fischer R

For further information in this module, please click
campus.tum.de or here.

Module Description

CH0115: Reactivity of Organic Compounds

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Modulpru¿fung stellt eine schriftliche Klausur von 90 Minuten dar. In dieser soll nachgewiesen werden dass die Studierenden die grundlegenden Prinzipien der organischen Reaktivität in begrenzter Zeit und ohne Hilfsmittel abrufen und auf bekannte Strukturen und Strukturänderungen gezielt anwenden können. Die Prüfungsfragen gehen über den gesamten Stoff des Moduls. Die Antworten erfordern teils eigene Berechnungen und Formulierungen, teils Ankreuzen von vorgegebenen Mehrfachantworten. Optional wird angeboten, dass die Studierenden, wenn sie mindestens 50% der freiwilligen schriftlichen Hausaufgaben richtig bearbeitet haben, ihre Modulnote um 0,3 auf die bestandene Klausur anheben können. Die Endnote setzt sich somit zusammen aus der bestandenen Klausur (100%), welche bei Bestehen von 50% der freiwilligen schriftlichen Hausaufgaben mit einem Bonus von 0,3 auf die Modulnote angehoben wird.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
"Aufbau und Struktur organischer Verbindungen", "Allgemeine und Anorganische Chemie"

Content:
Das Modul beschäftigt sich mit der Reaktivität organischer Verbindungen und hat zum Ziel, grundlegende Reaktionen der Organischen Chemie verständlich zu machen, wobei folgende Themenbereiche angesprochen werden: Radikalische Substitution, Nucleophile Substitution, Eliminierung, Addition, Aromatische Substitution, Oxidation/Reduktion, Reaktionen von Carbonylverbindungen und Umlagerungen. Auch werden wichtige Werkzeuge und Theorien zum Verständnis von Reaktionsmechanismen behandelt. Bestimmte Reaktionen in technischen Prozessen sowie die Relevanz organischer Reaktionen in biochemischen Prozessen werden diskutiert.

Intended Learning Outcomes:
Nach der Teilnahme am Modul sind die Studierenden in der Lage, grundlegende Reaktionen der Organischen Chemie bezüglich ihrer Reaktionsmechanismen anhand der grundlegenden Reaktivität der beteiligten Verbindungen zu verstehen. Sie sind in der Lage, diese Reaktivitäten auf ausgewählte technische und biochemische Prozesse anzuwenden. Die Studierenden können das Auftreten von Reaktionen in Abhängigkeit der Reaktionsbedingungen und Molekülstrukturen vorhersagen.

Teaching and Learning Methods:
Das Modul besteht aus einer Vorlesung (3 SWS) und einer begleitenden Übungsveranstaltung (1 SWS). Die Inhalte der Vorlesung werden im Vortrag und durch Präsentation vermittelt. Studierende sollen zur inhaltlichen Auseinandersetzung mit den Themen angeregt werden sowie zum weiterführenden Studium der Literatur. In der

Übung werden konkrete Beispiele zu den Inhalten der Vorlesung vertieft besprochen sowie grundlegende Konzepte aus der Vorlesung auf anders formulierte Probleme angewendet. Optional werden wöchentlich schriftliche Hausaufgaben zu behandelten Vorlesungsinhalten gestellt, die bei Abgabe korrigiert und mit individuellen Anmerkungen zur Lernkontrolle versehen werden.

Media:
Die Vorlesung verwendet verschiedene Medien inklusive Tafelarbeit und Projektion der wesentlichen Inhalte. Begleitend werden PDF-Handouts angeboten. Zur Repetition kann ein Vorlesungsskriptum bezogen werden. Übungsaufgaben werden in Übungsblättern (PDF) zur Verfügung gestellt.

Reading List:
Als Lehrbücher begleitend zur Vorlesung werden empfohlen:
a) R. Brückner, ¿Reaktionsmechanismen¿, 3. Aufl., Spektrum Verlag, 2004.
b) K. P. C. Vollhardt, N. Schore, ¿Organische Chemie¿, 5. Aufl., VCH-Wiley, 2011.
c) Clayden, Greeves, Warren, ¿Organische Chemie¿, 2. Aufl., Springer, 2013.

Responsible for Module:
Hintermann, Lukas; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:
Reactivity of Organic Compounds, Exercises (exercise, 1 SWS)
Hintermann L

Reactivity of Organic Compounds (lecture, 3 SWS)
Hintermann L (Widhopf V)

For further information in this module, please click
campus.tum.de or here.

Module Description

CH1019: Laboratory Course in Chemical Engineering

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
3	90	60	30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Modulleistung besteht ausschließlich aus einer Laborleistung. Die Laborleistung wird in Form eines Laborpraktikums erbracht und besteht aus der gleichgewichteten Mittelung der benoteten Ergebnisse der Einzelversuche aus dem Bereich der Technischen Chemie und Makromolekularen Chemie. Die Bewertung jedes Pflichtversuchs stützt sich auf folgende Beiträge: Einem Antestat, die Versuchsdurchführung, einem Abtestat und einem schriftlichen Bericht zum Versuch (Protokoll als Hausarbeit). Im Antestat weisen die Studierenden nach, dass Sie die theoretischen grundlegenden Aspekte zu den Versuchen verstanden haben und sich ausreichend für die Versuchsdurchführung vorbereitet haben. Dies ist notwendig, um die Sicherheitsaspekte beim Arbeiten in einem Labor sicherzustellen. Während der Versuchsdurchführung erlernen die Studierenden grundlegende Konzepte der Technischen Chemie und bekommen dadurch einen Überblick über die Zusammenhänge zu chemisch relevanten Themen. Die Studierenden können am Ende des Moduls grundlegende Konzepte anwenden um chemische Problemstellungen zu bearbeiten und verfügen über eine breite Stoffkenntnis. In den Berichten zeigen die Studierenden, dass sie die jeweiligen Versuche protokollieren, sie selbstständig auswerten und die eigenen Ergebnisse kritisch bewerten können. Hierzu zählt auch die Durchführung von Fehlerrechnungen.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Module: "Grundlagen der Technischen Chemie", "Reaktionstechnik und Katalyse für TUM-BWL" und "Angewandte Technische Chemie" (Makromolekulare Chemie)

Content:
Dieses Praktikum besteht aus zwei Teilen:
1. Teil Technische Chemie bei Dr. Erika Ember
Es wird ein Pflichtversuch (Transportlimitierung bei der Katalyse an festen Katalysatoren - Versuch A4) in 3er Gruppen durchgeführt. Es kann zusätzlich ein Wahlversuch (Stabilitätsverhalten eines kontinuierlich betriebenen Rührkesselreaktor - Versuch C4) durchgeführt werden.

2. Teil Makromolekulare Chemie bei Dr. Carsten Troll
Hier werden zwei Einzelversuche in 3er Gruppen durchgeführt. Die borhaltige Polysiloxane (Herstellung des "Hüpfenden Siliconkitts", nichtnewtonsche Flüssigkeit) und die Epoxidharze (Wie können die Eigenschaften von Epoxidharzen gezielt eingestellt werden?).

Intended Learning Outcomes:
Im Praktikum sollen die Studierenden das selbstständige experimentelle Arbeiten, die Auswertung von Messdaten und die wissenschaftliche Darstellung der Messergebnisse erlernen. Nach erfolgreicher Teilnahme an

dem Modul "Praktikum Technische Chemie für TUM-BWL" erinnern sich die Studierenden an diverse spezifische Versuchsaufbauten, -durchführungen und -auswertungen der Technischen Chemie und Makromolekularen Chemie. Speziell kennen die Studierenden diverse Transportphänomene in der Chemie, beispielsweise die Transportlimitierung bei der Katalyse an festen Katalysatoren. Im Teil Makromolekulare Chemie synthetisieren die Studierenden verschiedene Polymere und untersuchen deren mechanischen Eigenschaften. Sie sind in der Lage mikrostrukturelle Besonderheiten mit den resultierenden mechanischen Eigenschaften zu vernüpfen und die resultierenden Zusammenhänge zu verstehen. Sie können das zuvor erlente theoretische Wissen in der Praxis anwenden und auf weitere Problemstellungen übertragen.

Teaching and Learning Methods:
Das Modul besteht aus einem Praktikum (2 SWS), in welchem von den Studierenden Einzelversuche an speziell entworfenen Versuchsständen unter Anleitung eines Betreuers durchgeführt werden. Vor dem jeweiligen Versuch wird in einem Gespräch in die Handhabung des Versuchsaufbaus eingeführt. Die TeilnehmerInnen absolvieren das Praktikum in der Regel in Dreiergruppen.

Media:
Zu den Einzelversuchen werden Unterlagen (Skript zu Theorie und Messprogramm) zur Verfügung gestellt.

Reading List:
- F. Patat, K. Kirchner, Praktikum der Technischen Chemie
- P.W. Atkins, Physical Chemistry

Responsible for Module:
Hinrichsen, Kai-Olaf Martin; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
English title will be supplied (practical training, 2 SWS)
Lercher J, Rieger B, Hinrichsen K, Troll C

For further information in this module, please click
campus.tum.de or here.

Module Description

CH3153: Construction Chemistry 1

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsleistung wird in Form einer Klausur (90 Minuten) erbracht. Hierbei sollen die Studierenden zeigen, dass sie in der Lage sind die Vor- und Nachteile sowie die Anwendungseigenschaften typischer bauchemischer Zusatzmittel (wie z.B. Verflüssiger, Fließmittel, Verdickungsmittel und Wasserretentionsmittel) zu benennen und komplexe Fragestellungen hierzu lösen zu können. Darüber hinaus sollen die Studierenden in der Prüfung aufzeigen, dass sie die industrielle Herstellung dieser Zusatzmittel verstehen und schriftlich wiedergeben können. Zudem beschäftigt sich ein Teil der Prüfung mit dem detaillierten Wirkmechanismus dieser Zusatzmittel, den die Studierenden anhand der spezifischen Molekülstruktur herleiten und ausführlich diskutieren sollen. Die Prüfungsfragen umfassen den gesamten Modulstoff. Neben frei formulierten Fragen können auch kurze Rechenaufgaben Teil der Klausur sein. Es sind keine Hilfsmittel erlaubt.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fortgeschrittene Kenntnisse in allgemeiner und anorganischer Chemie, Grundkenntnisse der Polymerchemie.

Content:
Folgende theoretischen Modulinhalte werden im Modul thematisiert:
- Was ist Bauchemie?
- Herstellung und Anwendung von Lignosulfonat-basierten Verflüssigern
- Synthese und Eigenschaften von Polykondensat- und Polycarboxylat-Fließmitteln
- Wirkmechanismus von Fließmitteln
- Grundlagen der Rheologie
- Verdickungsmittel
- Synthese, Prüfmethoden und Wirkmechanismus von Wasserretentionsmitteln

Die theoretischen Modulinhalte werden durch einzelne Experimente ergänzt.

Intended Learning Outcomes:
Nach erfolgreicher Teilnahme am Modul sind die Studierenden in der Lage, die Unterschiede sowie die Vor- und Nachteile von bauchemischen Zusatzmitteln nachzuvollziehen. Die Studierenden erhalten einen umfassenden Überblick über eine Vielzahl von bauchemischen Zusatzmitteln, wodurch sie ihre Herstellung, Anwendungseigenschaften und ihre Wirkweise verstehen, diskutieren und gezielt analysieren können.

Teaching and Learning Methods:
Das Modul besteht aus einer Vorlesung (2 SWS) und einem Praktikum (1 SWS). Innerhalb der Vorlesung werden z.B. die industrielle Herstellung typischer bauchemischer Zusatzmittel und deren Wirkmechanismus durch Vortrag

des Dozierenden thematisiert. Dabei unterstützen Tafelanschriften und PowerPoint-Präsentationen die Darstellung des Lehrstoffs und tragen somit zum Verständnis der Vorlesungsinhalte bei. Durch den Vortrag des Dozierenden ist ein stufenweiser Aufbau der Modulinhalte (Grundlagen zu weiterführenden Inhalten) möglich. Die Vermittlung der Inhalte kann dem Lerntempo der Studierenden angepasst werden. Durch Fragen des Dozierenden an die Zuhörerschaft soll das Wissen gefestigt werden. Das parallel zur Vorlesung stattfindende Praktikum soll das Verständnis der Modulinhalte mittels einzelner Experimente (z.B. Fließmaßuntersuchungen von Verflüssigern und Fließmitteln im Zement- bzw. Gipsleim, Rheologiemessungen typischer Verdickungsmittel oder Testmethoden für Wasserretentionsmittel) ergänzen und zusätzlich fördern.

Media:
Tafelarbeit, Folien, PowerPoint, Laborarbeit

Reading List:
J. Plank, D. Stephan, Ch. Hirsch, ¿Bauchemie", in: Winnacker/Küchler: Chemische Technik-Prozesse und Produkte, Band 7 (Industrieprodukte), 5. Auflage, Verlag Wiley-VCH, Weinheim (2004), p. 1-168

Ramachandran V. S., Malhotra V. M., Jolicoeur C., Spiratos N., ¿Superplasticizers: Properties and Applications in Concrete¿, CANMET Publication, Canadian Government Publishing Centre Supply & Services Canada, ISBN 066017393X, 1998.

Responsible for Module:
Plank, Johann Peter; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Construction Chemicals I (lecture, 2 SWS)
Plank J

--- (practical training, 1 SWS)
Plank J

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

CH3154: Nano Materials

TUM School of Management

Module Level: Master	**Language:** German	**Duration:** one semester	**Frequency:** summer semester
Credits:* 5	**Total Hours:** 150	**Self-study Hours:** 105	**Contact Hours:** 45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsleistung wird in Form einer Klausur (90 Minuten) erbracht. Dabei zeigen die Studierenden, dass sie unterschiedliche Techniken mit den jeweiligen Vor- und Nachteilen zur Herstellung von Nanopartikeln verstehen und in eigenen Worten schriftlich wiedergeben können. Des Weiteren sollen die Studierenden mögliche Potentiale von Nanomaterialien analysieren und die Grundlagen dazu aufgreifen. Die Prüfungsfragen umfassen den gesamten Modulstoff. Es sind keine Hilfsmittel erlaubt.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fortgeschrittene Kenntnisse und Interesse an Nanomaterialien, der anorganischen Chemie, Polymerchemie und Kolloidchemie.

Content:
Das Modul umfasst die chemische und physikalische Herstellung sowie Analyse von Nanopartikeln und nanostrukturierten Materialien; außerdem werden die industrielle Herstellung sowie die Anwendung dieser Nanomaterialien behandelt.

Intended Learning Outcomes:
Nach erfolgreicher Teilnahme am Modul sind die Studierenden in der Lage:
¿ Unterschiedliche Techniken mit den jeweiligen Vor- und Nachteilen zur Herstellung von Nanopartikeln zu verstehen.
¿ Mögliche Potentiale von Nanomaterialien zu analysieren.

Teaching and Learning Methods:
Das Modul besteht aus einer Vorlesung (2 SWS) und einem Praktikum (1 SWS). Innerhalb der Vorlesung und des Praktikums werden z.B. die chemische und physikalische Herstellung sowie Analyse von Nanopartikeln und nanostrukturierten Materialien durch Vortrag des Dozierenden behandelt. Dabei unterstützen Tafelanschriften und PowerPoint-Präsentationen die Darstellung des Lehrstoffs und tragen somit zum Verständnis der Vorlesungsinhalte bei. Durch den Vortrag des Dozierenden ist ein stufenweiser Aufbau der Modulinhalte (Grundlagen zu weiterführenden Inhalten) möglich. Die Vermittlung der Inhalte kann dem Lerntempo der Studierenden angepasst werden. Durch Fragen des Dozierenden an die Zuhörerschaft soll das Wissen gefestigt werden. Das Praktikum veranschaulicht und ergänzt das Verständnis der Modulinhalte mittels einzelner Experimente.

Media:
PowerPoint, Tafelarbeit, Laborarbeit

Reading List:
Ozin, G. A.; Arsenault, A. C.: Nanochemistry: A Chemical Approach to Nanomaterials; Royal Society of Chemistry, 2009

Responsible for Module:
Plank, Johann Peter; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Nano Materials (lecture, 2 SWS)
Plank J

Nano Materials (practical training, 1 SWS)
Plank J

For further information in this module, please click
campus.tum.de or here.

Module Description

CH4115: Advanced Analytical Techniques

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsleistung wird in Form einer schriftlichen Klausur (90 Minuten) erbracht. In dieser soll nachgewiesen werden, dass in begrenzter Zeit und ohne Hilfsmittel vorgegebene analytische Fragestellungen der gesamten Chemie und der Umwelt in kurzer Zeit erkannt und messtechnisch angegangen werden können. Dazu gehören die wesentlichen physikochemischen Grundlagen gelöster oder suspendierter chemischer und biologischer Systeme und deren Verhalten bei Änderung der Einflussgrößen. In der Messtechnik soll das Basiswissen zu Spektroskopie, Trenntechniken und Elektroanalytik vorhanden sein, so dass im Berufsleben die richtige Wahl als Auftraggeber oder eigene erfolgreiche Arbeit im Messlabor möglich ist. Die Prüfungsfragen gehen über den gesamten Modulstoff. Die Antworten erfordern eigene Berechnungen und Formulierungen.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
"Allgemeine und Anorganische Chemie", "Experimentalphysik 1", "Experimentalphysik 2", "Grundlagen der Physikalischen Chemie", "Grundlagen der Analytischen Chemie".

Content:
Auswahl der Analysenverfahren anhand ihrer spektroskopischen, elektrochemischen Eigenschaften, sowie ihres Trennverhaltens in einer oder mehreren Phasen (Wanderungsgeschwindigkeiten/ Verteilungsverfahren); Probenvorbehandlung labiler Proben; Radiochemische und thermische Nachweisverfahren.

Intended Learning Outcomes:
Nach der Teilnahme am Modul "Fortgeschrittene analytische Verfahren" sind die Studierenden in der Lage, anorganische und organische Stoffsysteme mit den gängigen Analysenverfahren auf quantitative und qualitative Zusammensetzung beurteilen sowie analytische Schlüsselprobleme der Chemie und Umwelt messtechnisch angehen und analysieren zu können.

Teaching and Learning Methods:
Das Modul "Fortgeschrittene analytische Verfahren" besteht aus einer Vorlesung (4 SWS) in welcher die Inhalte im Vortrag, unterstützt durch Präsentationen (Folien und Powerpoint) und Tafelanschrieb, behandelt werden. Die Studierenden werden zur thematischen Auseinandersetzung mit der Literatur angeregt.

Media:
Folien, Tafelanschrieb, Powerpoint

Reading List:
a) D. Soog, F. Holler und S. Crouch "Instrumentelle Analytik", Springer Spektrum, Berlin, 2013.
b) R. Bock und R. Nießner "Trennungsmethoden der Analytischen Chemie" Walter de Gruyter, Berlin, 2014.

Responsible for Module:
Elsner, Martin; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Analytical Techniques (lecture, 4 SWS)
Elsner M (Popp C), Haisch C, Seidel M

For further information in this module, please click
campus.tum.de or here.

Specialization in Technology: Electrical Engineering and Information Technology (minor)

Wahlbereich 1

Technische Universität München

Module Description

EI10002: Principles of Electrotechnology [PiET]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
This module will be assessed in a written final examination (90 min) after the teaching weeks. In this examination it is to verify that the candidates are able to understand the general principles of electrical engineering and to solve relevant problems in the fields covered in this module in a limited time and without any resources. The examination will cover all parts of the lectures and exercises.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge of electricity and magnetism on high school level.
Basic knowledge of vector analysis.

Content:
Electrostatics:
Electrical charges, Coulomb's law, electrostatic fields, electrostatic potentials and voltages.

Dielectric materials:
Polarisation, dielectric displacement vector, Gauß' law, capacitors and capacitances.

Stationary electrical currents:
Current densities, local and integral Ohm's law, Kirchhoff's laws, resistors and resistivities, electrical networks, voltage and current sources, equivalent circuits, electrical energy and power.

(Electro-)magnetism:
Fundamental terms in magnetism, magnetic dipoles, Dia-, Para-, Ferromagnetism, magnetising field, magnetic induction, Amperé's law, electromagnetic induction, Faraday's law, inductors and inductivities, transformers.

Intended Learning Outcomes:
After participating in the modules lectures and exercises, students are able to understand and apply the basic physical principles of electrical engineering. They have acquired basic knowledge and understanding of some of the underlying problem-solving methods of electrical engineering.

Teaching and Learning Methods:
Teaching methods in lectures and exercises: Lecture-style instructions mainly on the blackboard.
In solving relevant exercises a deeper knowledge of the subject-matters presented in the lectures is sought.

Media:
The following media types are used in the lectures and exercises:
- Explanations and exemplifications on the black board, partly supplemented by computer-aided presentations.
- Downloads on the Internet.
- Exercises are provided with the objective that the students first should solve the problems independent by themselves, solution to the problems will be demonstrated in subsequent exercise sessions, and subsequently will be made available also via download on the Internet.

Reading List:
References will be presented in the first lecture hour.

Responsible for Module:
Schrag, Gabriele; Prof. Dr. rer. nat. habil.

Courses (Type of course, Weekly hours per semester), Instructor:
Principles in Electrotechnology (lecture, 3 SWS)
Wittmann F

Principles in Electrotechnology (exercise, 1 SWS)
Wittmann F [L], Hölzl W (Eßing S)

For further information in this module, please click
campus.tum.de or here.

Module Description

EI1289: Electrical Engineering

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsleistung wird in Form einer Klausur (90 min) erbracht. In dieser soll nachgewiesen werden, dass in begrenzter Zeit mit Hilfsmittel (2 handgeschriebene A4-Seiten) in den Veranstaltungen des Moduls behandelte Grundaufgaben gelöst werden können. Die Klausur besteht aus Fragen, in dem das Verständnis geprüft wird, und Aufgaben, in den z.B. eine Kurzschlussberechnung eines Transformators berechnet werden müssen. Mit den Prüfungsaufgaben wird das Erreichen der angestrebten Lernergebnisse des Moduls geprüft. Die Prüfungsfragen gehen über den gesamten Vorlesungsstoff.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Grundkenntnisse der elektrischen Energietechnik;

Content:
Elektrische Größen und Grundgesetze
Elektromagnetismus
Analogien des elektrischen und magnetischen Feldes
Wechselstromkreise
Drehstromsystem
Elektrische Maschinen
Grundlagen Leistungselektronik
Elektronische Bauelemente
Steuerungstechnik

Intended Learning Outcomes:
Nach der Teilnahme an der Modulveranstaltung ist der Studierende in der Lage, die Grundzüge der Elektrotechnik zu verstehen. Er kennt die Grundlagen der elektrischen und magnetischen Felder, ist vertraut mit Gleichstrom-, Wechselstrom- und Drehstromsystemen. Die Funktion und Beschreibung von elektrischen Maschinen wird grundsätzlich anhand von Beispielen erklärt. Die Grundlagen der Leistungselektronik sowie die wesentlichen Bauelemente wurden ihm vorgestellt.

Teaching and Learning Methods:
Das Modul besteht aus einer Vorlesung (2SWS) und einer Übung (1SWS). In der Vorlesung wird der Lernstoff mittels PowerPoint-Präsentation vermittelt. Details und Beispiele werden an der Tafel präsentiert. In der Übung werden konkrete Aufgabe und Beispiele an der Tafel vorgerechnet.
Als Lernmethode wird zusätzlich zu den individuellen Methoden des Studierenden eine vertiefende Wissensbildung

durch mehrmaliges Aufgabenrechnen in Übungen angestrebt.

Als Lehrmethode wird in der Vorlesungen und Übungen Frontalunterricht gehalten, in den Übungen auch Arbeitsunterricht (Aufgaben rechnen).

Media:
Folgende Medienformen finden Verwendung: Folienvortrag, Skriptum,Übungen, Laborführungen

Reading List:
" Elektrotechnik, Energietechnik
Elpers, Meyer, Skornitzke, Willner
Kieser Verlag, ISBN 3-8242-2022-9
" Taschenbuch der Elektrotechnik
Kories, Schmidt-Walter
Verlag Harry Deutsch, ISBN 3-8171-1563-6
" Fachkunde Elektrotechnik
Verlag Europa-Lehrmittel, ISBN 3-8085-3020-0
" Einführung in die Elektrotechnik
Jötten, Zürneck
Uni-Text, Vieweg Verlag
" Grundlagen der Elektrotechnik
Phillipow,
Hüthig Verlag
" Theoretische Elektrotechnik
Simonyi,
Deutscher Verlag der Wissenschaften

"

Responsible for Module:
Witzmann, Rolf; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Electrical Engineering (LB-BF-MT) (lecture with integrated exercises, 3 SWS)
Würl T [L], Witzmann R, Würl T

For further information in this module, please click
campus.tum.de or here.

Module Description

EI29821: Principles of Information Engineering

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsleistung wird in Form einer Klausur (75 min) erbracht. In dieser soll nachgewiesen werden, dass in begrenzter Zeit und ohne Hilfsmittel in den Veranstaltungen des Moduls behandelte Grundaufgaben der Informationstechnik gelöst werden können. Mit den Prüfungsaufgaben wird das Erreichen der angestrebten Lernergebnisse des Moduls geprüft. Die Prüfungsfragen gehen über den gesamten Vorlesungsstoff.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Grundlegende (Schul-)kenntnisse der Algebra und der Integralrechnung.

Content:
Klassifizierung von Signalen, Abgrenzung Datenverarbeitung - Datenübertragung. Grundlegende Elemente der Datenverarbeitung: Beschreibung von Schaltnetzen, Boolesche Algebra, Schaltfunktionen, disjunktive und konjunktive Normalform, Minimierung von Schaltfunktionen. Zahlensysteme, Rechnen im Dualsystem. Schaltwerke. Maschinenprogrammierung. Grundlegende Elemente der Datenübertragung: deterministische und stochastische Signale. Periodische Signale, reelle und komplexe Darstellung, Fourier-Reihenentwicklung. A/D und D/A-Umsetzung. Grundlage statistischer Methoden, Zufallsgrößen, Wahrscheinlichkeitsdichte, Verteilungsfunktionen und Momente. Berechnung der Bitfehlerwahrscheinlichkeit digitaler Übertragungssysteme. Einfache Codes zur Fehlerkorrektur.

Intended Learning Outcomes:
Durch die Teilnahme an den Modulveranstaltungen erhalten die Studierenden Grundkenntnisse in ausgewählten Themenbereichen der Informationstechnik. Sie haben die Fähigkeit, auf den behandelten Themenfeldern grundlegende Aufgaben der Schaltungsentwicklung und Schaltungs- bzw. Signalanalyse durchzuführen.

Teaching and Learning Methods:
Das Modul besteht aus einer Vorlesung (2SWS) und einer Übung (2SWS). In der Vorlesung wird der Lernstoff mittels PowerPoint-Präsentation vermittelt. Details und Beispiele werden an der Tafel präsentiert. In der Übung werden konkrete Aufgabe und Beispiele an der Tafel vorgerechnet.
Als Lernmethode wird zusätzlich zu den individuellen Methoden des Studierenden eine vertiefende Wissensbildung durch mehrmaliges Aufgabenrechnen in Übungen angestrebt.

Als Lehrmethode wird in der Vorlesungen und Übungen Frontalunterricht gehalten, in den Übungen auch Arbeitsunterricht (Aufgaben rechnen).

Media:
Folgende Medienformen finden Verwendung:
- Präsentationen
- Skript
- Übungsaufgaben mit Lösungen als Download im Internet

Reading List:
Skriptum zur Vorlesung, erhältlich in FSEI

Responsible for Module:
Hanik, Norbert; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Grundlagen der Informationstechnik (LB) (lecture, 4 SWS)
Hanik N, Kernetzky K

For further information in this module, please click
campus.tum.de or here.

Wahlbereich 2

Module Description

EI04024: Python for Engineering Data Analysis ¿ From Machine Learning to Visualization [Python für technische Datenanalyse]

- von maschinellem Lernen zu Visualisierungen

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Bachelor	German/English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	75	75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:

Die Prüfung wird als Laborleistung ausgeführt. Die Leistung der Studenten wird durch regelmäßige Hausaufgaben überprüft; zugleich entsteht damit ein kontinuierliches Praktikumsprotokoll, das als Grundlage für die Benotung dient. Im Zuge der letzten Praktikumstermine wird ein individueller Abschlussbericht für eine umfänglichere Problemstellung angefertigt, welcher anschauliche Grafiken in Publikationsqualität enthält. Das stellt sicher, dass die Studenten in der Lage sind,

(1) eine konsistente Forschungsfrage zu formulieren

(2) einen signifikaten Teil der in den Praktikumsübungen erlernten Techniken und Werkzeuge korrekt anzuwenden

(3) unabhängig zu entscheiden, welche Methoden für ein spezifisches Problem anzuwenden sind

Um 100% der dort vergebenen Punkte zu erreichen, müssen 70% der regulären Aufgaben erfolgreich bearbeitet werden; 2er-Gruppen können eine Lösung einreichen.

Repeat Examination:

Next semester

(Recommended) Prerequisites:

Keine, ein Programmier/Algorithmik-Kurs wird empfohlen (und ist auch im Kern-Curriculum in Form des Moduls IN8009 enthalten)

Content:

Mit dem Erfolg datenzentrierter Geschäftsmodelle, die oft um maschinelles Lernen oder KI aufgebaut sind, wurden ¿data science¿ und Datenmodellierung in den Blickpunkt verschiedenster Disziplinen gebracht - von der Fabrikautomatisierung über Geschäftsanalytik zu den Materialwissenschaften.

Im Zuge dieser Entwicklung hin zu einem ¿Data-Science¿-Paradigma werden die zugehörigen statistischen Datenanalyse-Konzepte verstärkt als neuartige Methodiken in alle wissenschaftlichen und Ingenieurs-Disziplinen eingebracht, die historisch schon auf die breite Anwendung einfacher und voraussagbarer Analysmethoden bauten (z.B. lineare Regression und 2D-Visualisierungen). Bedauerlicherweise wird darüber oft über das beträchtliche Erbe dieser ¿neuen¿ Methoden im Ingenieursbereich (z.B. Forrester et. al., 2008) hinweggesehen und die neuen Methoden unkritisch angewandt.

In Hinblick darauf versucht dieses Praktikum die Programmiersprache Python als Werkzeug für Ingenieure und Wissenschaftler einzuführen, mit dem alle typischerweise im Laborkontext entstehenden Datenanalyse-Aufgaben durchgeführt werden können (Datenaufbereitung, Statistikberechnung, lineare Modellierung, Visualisierung); zudem wird der Bezug von einfachen statistischen Modellen zu Machine Learning Methoden und ihren inhärenten Defiziten dargestellt.

Falls ein Studierender hauptsächlich effizientes Programmieren in Python lernen will, ist das Modul EI0508 ¿Projektpraktikum Python¿ passender; diejenigen, die an einer fokussierten Einführung der Statistik, die maschinellem Lernen zugrunde liegt, interessiert sind, sollten EI04016 oder einen Kurs der Mathematik-Fakultät belegen.

Eine grobe Übersicht der einzelnen Abschnitte des Praktikums könnte wie folgt aussehen:
(0) Kickoff + Motivation
(1) Einführung in die Programmiersprache Python
(2) Datenerfassung ¿ Interaktion mit Laborgeräten, Datenbanken, MS Excel und dem Internet
(3) Datenvisualisierung ¿ ¿do¿s and dont¿s¿
(4) Datenmodellierung ¿ einfach statistische Techniken, um ein Datenmodell zu erstellen
(5) (Statistisches) Lernen ¿ kann ein Datenmodell zu Voraussage genutzt werden?

Intended Learning Outcomes:
Nach erfolgreicher Kursteilnahme sind die Studenten in der Lage:
- algorithmische Probleme mit Python zu lösen
- selbstständig grundlegende Datenanalyse-/ Statistikaufgaben auf Datensätzen durchzuführen
- die verfügbaren Werkzeuge für 2D-Visualisierung (inkl. Bildern) anzuwenden und mit 3D-Datensätzen und den verbundenen Tools zu arbeiten (letzeres kann im Abschlussprojekt vertieft werden)
- Konzepte verschiedener Methoden (lineare Regression, Regularisation, neuronale Netzwerke) für die Modellierung (hoch-dimensionaler) Datensätze und den Bezug zu grundlegender Statistik zu verstehen
- die Einschränkugen der erwähnten Methoden bei Einsatz für Vorhersage und Optimierung zu verstehen
- Erfahrung mit Werkzeugen auf dem Stand der Technik zum Erstellen von Datenanalyse-Workflows mit Python vorzuweisen (jupyter, pandas)

Teaching and Learning Methods:
Während der regelmäßigen Übungen werden die Studenten einfache Datenanalyse-Probleme im Computerraum lösen (zweimal wöchentlich). Dieser Teil wird mit Folien und weiteren Lernmitteln auf Moodle unterstützt. Um einen gleichbleibenden Fortschritt zu fördern, sind weitere Aufgaben im Eigenstudium zu lösen.

Es wird ein über das Internet zugänglicher Server zur Verfügung gestellt, wo Studenten Jupyterhub oder einen klassischen Editor für ihre Programmieraufgaben nutzen können.

Media:
E-learning course in moodle

Reading List:
- Python 3 ¿ Reference documentation [https://docs.python.org/3/]
- Langtangen, H.P.: A Primer on Scientific Programming with Python, Springer (2016)
- Sweigart, Al: Automate the boring stuff with Python [https://automatetheboringstuff.com/]
- Forrester et. al.: Engineering Design via Surrogate Modelling: A Practical Guide, Wiley (2008)

weitere, spezialisierte Literatur zu spezifischen Problemstellungen wird während des Kurses zur Verfügung gestellt.

Responsible for Module:
Gagliardi, Alessio; Prof. Dr. rer. nat.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click
campus.tum.de or here.

Module Description

EI0625: Communication Networks

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Im Rahmen einer 90 minütigen schriftlichen Klausur wird überprüft, inwieweit Studierende die Kommunikationsnetzen und deren Funktionsblöcken zugrundeliegenden Konzepte wiedergeben können. Dafür müssen Studierende Fragen beantworten und Analysemethoden zur Netzbewertung einsetzen und Optimierungsmöglichkeiten aufzeigen können.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
keine Voraussetzungen.

Content:
* Übertragungsverfahren, Multiplextechniken, Durchschalte- und Paketvermittlung, Signalisierung, Adressierung, Nachrichtenaustausch
* Leistungsbewertung, Einführung in die Verkehrstheorie (Berechnung von Verlust- und Wartesystemen)
* Grundlegende Kommunikationsprotokolle (ARQ, Fensterprotokolle)
* Netzstrukturen, Netzgraphen, Algorithmen, Routing
* Einführung in die Netzplanung und Optimierung
* Fehlertoleranz und Verfügbarkeit
* Mobilitätsmanagement
* Beispiele heutiger Netze (Internet, Telefonnetz, Mobilfunknetz), Dienste, Anwendungen, Architekturkonzepte

Intended Learning Outcomes:
Nach erfolgreichem Abschluss des Moduls ist die Studierende/der Studierende in der Lage, grundlegende Konzepte von Kommunikationsnetzen und deren Funktionsblöcke zu verstehen, grundlegende graphen- und verkehrstheoretische Analysemethoden zur Netzbewertung, grundlegende Methoden des Protokollentwurfs, der Netzplanung und Optimierung sowie Routingverfahren anzuwenden.

Teaching and Learning Methods:
Als Lernmethode wird zusätzlich zu den individuellen Methoden der Studierenden/des Studierenden eine vertiefende Wissensbildung durch mehrmaliges Aufgabenrechnen in Übungen angestrebt.

Als Lehrmethode wird in der Vorlesungen Frontalunterricht, in den Übungen Arbeitsunterricht (Aufgaben rechnen) gehalten.

Zusätzlich erarbeiten die Studierenden selbsständig anhand wissenschaftlicher Fachartikel weitere Grundlagen und üben damit das Lesen und Verstehen wissenschaftlicher Literatur.

Media:
Folgende Medienformen finden Verwendung:
- Präsentationen
- Skript
- Übungsaufgaben mit Lösungen als Download im Internet
- ausgewählte wissenschaftliche Aufsätze

Reading List:
Folgende Literatur wird empfohlen:
- Tanenbaum A. S.: Computer Netzwerke, Wolframs Verlag
- Killat U.: Entwurf und Analyse von Kommunikationssystemen, Vieweg+Teubner Verlag
- Krüger G., Reschke D.: Telematik, Fachbuchverlag Leipzig

Responsible for Module:
Kellerer, Wolfgang; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Communication Networks (lecture with integrated exercises, 4 SWS)
Kellerer W, Ayan O

For further information in this module, please click
campus.tum.de or here.

Module Description

EI10003: Analog Electronics [AE]

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Bachelor	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	100	50

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
This module will be assessed in a written final examination (90 min) after the teaching weeks. In this examination it is to verify that the candidates are able to understand the general principles of analog electronic circuits and to solve simple but relevant problems in the fields covered in this module in a limited time and without any resources. The examination will cover all parts of the lectures and exercises of this module.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Subject matters as presented in the module "Principle of Electrotechnology"
Calculus; complex numbers and operations for ac signal analysis

Content:
Electronic signals
Circuit analysis (dc, ac)
Electrical characteristics of electronic devices
Electronic filters
Basics of semiconductor¿s physics
PN Junctions, pn diodes
Transistors
Basic Transistor circuits
Amplifiers

Intended Learning Outcomes:
After participating in the modules lectures and excercises, students are able to
- understand and apply the basic principles of analog electronic cicuits
- have acquired basic knowledge and understanding of some of the basic problem-solving methods of electronic cicuits.

Teaching and Learning Methods:
Teaching methods in the lectures and excercises: frontal teaching with presentations and on the blackboard.
In solving relevant exercises a deeper knowledge of the subject matters of the lessons is sought.

Media:
The following media types are used in the lectures and excercises:
- Presentations (also for downloads on the Internet)

- Explanations and exemplifications on the black board
- Exercises are provided with the objective that the students first should solve the problems independent by themselves, the solutions to the problems will be demonstrated in subsequent excercise sessions, and subsequently will be made available also via download on the Internet.

Reading List:

Responsible for Module:
Schrag, Gabriele; Prof. Dr. rer. nat. habil.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click
campus.tum.de or here.

Module Description

EI2986: Telecommunication I - Signal Representation

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsleistung wird in Form einer Klausur (75 min) erbracht. In dieser soll nachgewiesen werden, dass in begrenzter Zeit und ohne Hilfsmittel in den Veranstaltungen des Moduls behandelte Grundaufgaben der linearen Systemtheorie gelöst werden können. Mit den Prüfungsaufgaben wird das Erreichen der angestrebten Lernergebnisse des Moduls geprüft. Die Prüfungsfragen gehen über den gesamten Vorlesungsstoff.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Grundlegende Kenntnisse der Differential- und Integralrechnung.

Content:
Signale und Spektren: stochastische, periodische, aperiodische Signale. Fourierreihe, Fourierintegral und Fouriertransformation. Systemtheorie linearer zeitinvarianter Systeme: Übertragungsfunktion, Impulsantwort, lineare Verzerrungen, Faltung. Beispiele linearer Systeme: elektrische Tiefpass-Filter, kohärent-optische Fouriertransformation. Einfache nichtlineare Systeme.

Intended Learning Outcomes:
Durch die Teilnahme an den Modulveranstaltungen erhalten die Studierenden fundierte Kenntnisse der der Fourier-Reihenentwicklung und Fourier-Transformation eindimensionaler Signale sowie der Analyse linearer Systeme mit Methoden der linearen Systemtheorie. Sie haben die Fähigkeit, lineare zeitinvariante Systeme im Zeit- und Frequenzbereich zu analysieren und auftretende Störungen zu berechnen und zu bewerten.

Teaching and Learning Methods:
Das Modul besteht aus einer Vorlesung (2 SWS) und einer Übung (1 SWS) . In der Vorlesung wird der Lernstoff mittels PowerPoint-Präsentation vermittelt. Details und Beispiele werden an der Tafel präsentiert. In der Übung werden konkrete Aufgabe und Beispiele an der Tafel vorgerechnet.
Als Lernmethode wird zusätzlich zu den individuellen Methoden des Studierenden eine vertiefende Wissensbildung durch mehrmaliges Aufgabenrechnen in Übungen angestrebt.

Als Lehrmethode wird in der Vorlesungen und Übungen Frontalunterricht gehalten, in den Übungen auch Arbeitsunterricht (Aufgaben rechnen).

Media:
Folgende Medienformen finden Verwendung:
- Präsentationen
- Skript
- Übungsaufgaben mit Lösungen als Download im Internet

Reading List:
Skriptum zur Vorlesung, erhältlich in FSEI

Responsible for Module:
Hanik, Norbert; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Telecommunications I (LB) (lecture with integrated exercises, 3 SWS)
Hanik N

For further information in this module, please click
campus.tum.de or here.

Module Description

EI3199: Laboratory Analog Electronics for TUM-BWL

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Benotung der Durchführung der Praktikumsversuche sowie der schriftlichen Protokolle und schriftlichen Ausarbeitungen zu den Praktikumsversuchen. Die Ausarbeitungen werden in Form von schriftlichen Hausarbeiten durchgeführt.

Repeat Examination:

(Recommended) Prerequisites:
Kenntnisse der Inhalte aus den Vorlesungen und den Übungen zur "Grundlagen der Elektrotechnik (TUM-BWL)" und "Schaltungselektronik (TUM-BWL)" aus den vorausgegangenen Semestern. Festgestellt durch bestandene Klausur zu den Vorlesungen und den Übungen zur "Schaltungselektronik (TUM-BWL)

Content:
Messtechnik für Gleich- und Wechselgrößen
Strom-/Spannungsversorgungen (Netzteile), Signalgeneratoren
Digitalmultimeter, Oszilloskope
Messung von Kennlinien
Aufbau und Charakterisierung einfacher elektronischer Schaltungen mit diskreten und integrierten Bauelementen der Elektronik
(z.B. aktive Filter, Verstärker, ...)

Intended Learning Outcomes:
Fertigkeiten im Umgang mit elektronischen Bauelementen und Messgeräten
Dimensionierung und Charakterisierung von Bauelementen und elektronischen Grundschaltungen.

Teaching and Learning Methods:
Lehrmethode ist eine Kombination aus Frontalunterricht und praktischen Anwendungen im Labor

Media:
Folgende Medienformen finden Verwendung:
- Frontalunterricht
- Skripte und Versuchsanleitungen als Download im Internet (TUMonline)
- praktische Arbeiten im Labor

Reading List:
H. Hartl, E. Krasser, G. Winkler, W. Pribyl, P. Söser: Elektronische Schaltungstechnik (Pearson)
E. Schrüfer: Elektrische Messtechnik (Hanser)

Responsible for Module:
Schrag, Gabriele; Prof. Dr. rer. nat. habil.

Courses (Type of course, Weekly hours per semester), Instructor:
Analog Electronics (practical training, 4 SWS)
Wittmann F

For further information in this module, please click
campus.tum.de or here.

Module Description

EI4802: Basics of High-Frequency Engineering [GdHF]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In einer schriftlichen Klausur (90 min) ohne Unterlagen weisen die studierenden durch Berechnung vorgegebener Sachverahlte nach, dass sie hochfrequenztechnisches Verhalten von Bauelementen, Schaltungen und Leitungen korrekt wiedergeben können.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
keine

Content:
1. Elektromagnetische Wellen
- Einführung
- Induktions- und Durchflutungsgesetz
- Skineffekt
- Ebene Wellen
- Leitungswellen
- Leitungstheorie
- Streuparameter
- Smith-Diagramm
- Blindleitungen und Leitungsresonatoren
2. Mikrostreifenleitungstechnik
- Eigenschaften von Streifenleitern
- Grundelemente
3. Elektrische Werkstoffe und Bauelemente bei höheren Frequenzen
- Leiter und Widerstände
- Kondensatoren
- Induktivitäten
4. Passive lineare Schaltungen
- Transformationsschaltungen
- Resonanzschaltungen
- Breitbandschaltungen
- Filterschaltungen

Intended Learning Outcomes:
Nach dem erfolgreichen Abschluss des Moduls haben die Studierenden ein grundlegendes Verständnis des hochfrequenztechnischen Verhaltens von Bauelementen, Schaltungen und Leitungen.

Teaching and Learning Methods:
Als Lernmethode wird zusätzlich zu den individuellen Methoden des Studierenden eine vertiefende Wissensbildung durch mehrmaliges Aufgabenrechnen in Übungen angestrebt.

Als Lehrmethode wird in der Vorlesungen Frontalunterricht, in den Übungen Arbeitsunterricht (Aufgaben rechnen) gehalten.

Media:
PowerPoint, Skriptum, Übungsaufgabensammlung

Reading List:
Detlefsen, J. ; Siart, U.: Grundlagen der Hochfrequenztechnik. München : Oldenbourg, 2012, 4. Auflage

Responsible for Module:
Siart, Uwe; Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Fundamentals of RF Engineering (lecture with integrated exercises, 4 SWS)
Paulus A [L], Siart U, Paulus A

For further information in this module, please click
campus.tum.de or here.

Specialization in Technology: Information Technology and Electronics (major)

Module Description

EI0631: Media Technology

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The type of examination is a written exam with 90 minutes duration. Students solve selected problems based on the introduced concepts and equations. Additionally, they answer questions about the lecture content and explain in their own words selected methods from the lecture. Students are allowed to bring 4 pages of handwritten notes and a non-programmable calculator.
Matlab assignments with voluntary participation are offered during the semester and can be used to improve the final grade of the course.

The final grade is composed of the following elements:
- 100% final exam

Successful completion of the Matlab assignments leads to a bonus of 0.3 on the final grade in case the final is passed. The Matlab assignments are successfully completed if at least an average of 65% is obtained when submitting the solutions to the module tutor.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Higher Mathematics, Linear Algebra, Signal Processing

Following modules should have been accomplished before participation:
- Signals
- Introduction to signal processing
- Systems

Content:
image construction camera models and coordinates, mapping from world to pixel coordinates, camera calibration, sterea camera systems, image synthesis,the rasterization of geometric primitives, geometric scene description using polygon meshes and parametric surfaces, illumination of surfaces, shading, texture mapping, rendering pipeline, analog video, color TV systems, digital video, format conversion

Intended Learning Outcomes:
Upon completion of the module, students are able to:
- characterize the fundamental principles of information retrieval using the example of text and image search and to evaluate the performance of different approaches
- develop a simple system for media search and to evaluate its performance
- describe the creation of images and mathematically compute the mapping between world coordinates and pixel

coordinates for single and stereo camera systems
- perform external and internal camera calibration and analyze the calibration error
- describe the fundamental principles of image synthesis including the rasterization of geometric primitives, geometric scene description using polygon meshes and parametric surfaces, illumination of surfaces, shading, texture mapping
- describe the basic steps of the rendering pipeline and evaluate it for simple scenes with point light sources
- characterize analog and digital video and to analyze their differences
- compute the influence of phase errors for color TV systems NTSC, SECAM, and PAL.
- perform the conversion between different formats for digital TV signals

Teaching and Learning Methods:
Teaching and learning methods consist of presentations during the lecture and the exercises. Moreover, the students will improve their knowledge by use of scientific literature and implement selected concepts of the lecture using matlab during the voluntary project during the semester.

Media:
Following forms of media are applied:
- presentations
- script
- exercises with solution (downloadable from the internet)

Reading List:
Following literature is recommended:
- R. Steinmetz, Multimedia-Technology Springer-Verlag, 3. überarb. Auflage, 2000.
- Foley et al, Computer Graphics: Principles and Practice, Addison Wesley, zweite Auflage, 1995.
- Manning et al., Introduction to Information Retrieval, Cambridge University Press, 2008.
- U. Schmidt, Professionelle Videotechnik, Springer-Verlag, 2000.

Responsible for Module:
Steinbach, Eckehard; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Media Technology (lecture with integrated exercises, 4 SWS)
Steinbach E, Adam M

For further information in this module, please click
campus.tum.de or here.

Module Description

EI0666: Project Course Nanoelectronics and Nanotechnology [PPNANO]

Project Course Nanoelectronics and Nanotechnology
TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German/English	one semester	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	75	75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a 15 min oral presentation with subsequent discussion of the medthods and results that have been gained in the project (50%). Furthermore, it includes the preparation of a written technical report, summarizing the main methods used, and classifying the gained results compared to state-of-the-art devices (50%).
By the presentation, the ability is tested to understand a technical/scientific subject, to analyze and evaluate facts and factors of influence, to summarize the subject and present it to an audience, and to stand a discussion about the presented subject.By the written summary the ability is tested to summarize the major facts and the conclusion of a presentation in clear and concise manner, both in a short abstract (150words) as well as in a 4 page technical report (conferecne paper style of IEEE).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
For Bachelor EI students the following modules are recommended before taking the course:
- Physik für Elektroingenieure
- Werkstoffe der Elektrotechnik
- Elektronische Bauelemente

Content:
In the Praktikum it will be possible to work on a selected nanofabrication and nanodevices projects,covering a large spectra of topics. Among them are : Electronic, optical and transport properties of nanostructures; Quantum semiconductor devices; Fabrication and characterization techniques of nanotechnology; Molecular electronics and optoelectronics; Organic materials for electronics: self-assembled monolayers; conducting polymers; carbon nanotubes. Circuit implementations and architectures for nanostructures.

Intended Learning Outcomes:
After completion of the course, the students are able to interpret properties of nanoelectronic structures and devices. They are able to apply methods of nanoelectronic device fabrication. They are able to compare different physical effects of nanoelectronic devices in the light of device and system applications. Furthermore they are able to analyze nanostructures and nanodevices as well as their system integration.

Teaching and Learning Methods:
In the framework of the lab course, nanoelectronic structures and devices will be desigend, fabricated and characterized. Small tutorials will provide the theoretical background, additional reading will inspire the students to deepen their knowledge. Fabrication and characterisation tasks are supervised by institute scientists and technical staff. The students will present their results in a scientific talk and a written technical report.

Media:
Information and teaching material will be provided in form of presentation slides, scientific papers, handout notes and topic related scripts.

Reading List:
Presentation slides, topic related short instructions, technical notes, white paper, state-of-the-art scientific literature provided during the course by the tutor.

Responsible for Module:
Becherer, Markus; Prof. Dr.-Ing. habil.

Courses (Type of course, Weekly hours per semester), Instructor:
Projektpraktikum Nanoelektronik und Nanotechnologie (research lab training, 5 SWS)
Becherer M [L], Becherer M, Mendisch S

For further information in this module, please click
campus.tum.de or here.

Module Description

EI7331: Algorithm for Digital Circuit Design

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	120	30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Modulprüfung ist schriftlich (60 min) ohne Unterlagen. Die Teilnehmer beantworten Verständnisfragen zu Methoden und Werkzeugen für die Entwicklung integrierter Schaltungen, einschließlich einem Fragenblock zum Literaturstudium. Als Prüfungsleistung soll ein vertieftes Verständnis für die Leistungsfähigkeit und die Beschränkungen dieser Methoden und Werkzeuge, sowie die Kompetenz zur kritischen Reflektion bezüglich deren Einsatz nachgewiesen werden.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Grundlagen der integrierten Schaltungstechnik, z.B. aus dem Modul "Digitaltechnik"

Content:
Folgende Themen werden behandelt: Abstraktionsebenen beim Entwurf integrierter Schaltungen, Leistungsfähigkeit und Grenzen der Simulation und der einzelnen Werkzeuge, Leistungsfähigkeit und Grenzen verschiedener Testmethoden, Technisch-organisatorische Aufgaben eines Projektleiters bei der ASIC-Entwicklung, Umsetzen der weltweit wichtigsten Qualitätssicherungs-Vorschriften (ISO 9000) bei der ASIC-Entwicklung.

Intended Learning Outcomes:
Die Teilnehmer sollen nach der Veranstaltung Methoden und Werkzeuge für die Entwicklung Integrierter Schaltungen analysieren und bewerten können. Dies schließt technische, organisatorische und wirtschaftliche Themen ein, mit denen ein zukünftiger VLSI-Entwicklungsingenieur konfrontiert wird.

Teaching and Learning Methods:
Als Lernmethode wird zusätzlich zu den individuellen Methoden des Studierenden eine vertiefende Wissensbildung durch anschauliche Fallstudienbetrachtungen angestrebt.

Als Lehrmethode wird in der Vorlesung Frontalunterricht, ergänzt durch Gruppendiskussionen, verwendet.

Eigenstudium des ausgeteilten Materials. In der Vorlesung werden Publikationen zu den prüfungsrelevanten Fallstudien ausgegeben, die von den Studierenden selbständig analysiert werden.

Media:
Folgende Medienformen finden Verwendung:

- Präsentationen mit Laptop und Beamer
- Tafelanschrieb
- Skript, gedruckt von der Fachschaft und online über e-learning verfügbar
- Literatur (wird in der Vorlesung verteilt)

Reading List:
Folgende Literatur wird empfohlen:
- Reifschneider: ""CAE-gestützte IC-Entwurfsmethoden"", Prentice Hall
- Weste, Harris: ""CMOS VLSI Design, A Circuits and Systems Perspective"", Addison Wesley

Responsible for Module:
Stechele, Walter; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
EI4251 Design of Integrated Circuits (lecture, 2 SWS)
Stechele W

For further information in this module, please click
campus.tum.de or here.

Module Description

EI7585: Clinical Applications of Computational Medicine

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	150	30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
After three introductory lectures, the students work in small groups on different projects. Projects are focused on actual clinical applications from some of these areas: multiple sclerosis, obstetrics, cardiovascular disease, fall prevention/detection and sport medicine. The projects will be fixed in detail after the introductory lectures according to the special interests and expertise of the students and the resources. The work done in previous semesters are available at the website of the department to serve as orientation.
In general, a project encompasses these tasks: study design, data collection, algorithm development and validation, data analysis and summary of results.
Students should prepare a report (maximum 4 pages) including the details of their work as well as a set of slides for the final presentation. The The results will be presented to the audience and defended at the end of the semester. External guests are invited to attend and participate in the final presentation.
The quality of the written report, the presentation and the discussion contribute each as 1/3 of the final grade.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Analysis, classical mechanics, fundamentals in electrical engineering, basics in social psychology, basic knowledge of R/Matlab and statistics

Content:
Computational Medicine is a new scientific field in the intersection between mathematics, physics, biostatistics, computer science, electronics, biomedical engineering and medicine. We focus on actual clinical applications of complex, interdisciplinary solutions for problems in healthcare. Using examples from areas mostly from multiple sclerosis, obstetrics, cardiovascular disease, fall prevention/detection and sport medicine we will explore some of the following important aspects: data collection, biostatistical modelling, filtering, pattern recognition, alarms, prediction, validation, development & certification of web-based tools for clinical decision making.

Intended Learning Outcomes:
At the end of the module the students are able to understand the problems and key success factors for business models in computational medicine/telemedicine with examples in selected medical areas (multiple sclerosis, obstetrics, cardiovascular disease, fall prevention/detection, exercise therapy).
They are able to apply basic signal processing techniques to solve specific problems (filtering and analysis of data

from mobile accelerometry/ECG). They also should be able to understand the scientific method to conduct exploratory research generating and testing hypothesis, looking at events, collecting data, analyzing information and reporting the results. In addition, it is expected that they improve their written and oral communications skills by the creation of a scientific report and holding a public presentation.

Teaching and Learning Methods:
Zunächst wir in einer Reihe von 3 Vorlesungen das Basiswissen zu den einzelnen Themen vermittelt. Darufhin erfolgt eine den Fähigeiten und Interessenslage angepassten Themenauswahl ("matching") zur Vertiefung. Kleingruppen (1-3 Studenten) führen mit entsprechender Unterstützung ein kleines Projekt durch, das am Ende präsentiert und diskutiert wird. Also ist die Lehr- und Lernmethode ein Mix aus Vorlesung, Seminar, Übung und Labor.

Media:
multimediale Präsentationen, ""hands-on"" Erfahrung mit Medizinprodukten/Messgeräten, interaktive OLAP-Web-Tools, Besuche bei Medizintechnikfirma/klinischen Partnern.

Reading List:
" Motl RW, Weikert M, Suh Y, Sosnoff JJ, Pula J, Soaz C, Schimpl M, Lederer C, Daumer M: Accuracy of the actibelt® Accelerometer for Measuring Walking Speed in a Controlled Environment among Persons with Multiple Sclerosis. Gait and Posture (2011 Sep 22. [Epub ahead of print])
" Schimpl M, Moore C, Lederer C, Neuhaus A, Sambrook J, Danesh J, Ouwehand W, Daumer M: Association between walking speed and age in healthy, free-living individuals using mobile accelerometry - a cross-sectional study. PLoS ONE 6(8): e23299. doi:10.1371/journal.pone. 0023299
" Schimpl M, Lederer C, Daumer M: Development and validation of a new method to measure walking speed in free-living environments using the actibelt platform. PLoS ONE 6(8): e23080. doi:10.1371/journal.pone.0023080
" Scalfari A, Neuhaus A, Daumer M, Ebers GC, Muraro PA: Age and disability accumulation in Multiple Sclerosis. Neurology (published ahead of print September 14, 2011)
" Daumer M, Neuhaus A, Herbert J. Ebers G: Prognosis of the individual course of disease: the elements of time, hetereogeneity and precision, Journal of the Neurological Sciences 287: S50-S55, 2009
" Ebers G., Heigenhauser L., Daumer M., Lederer C., Noseworthy J.: Disability as an outcome in clinical trials . Neurology 71 (9), 624-631, 2008
" Daumer M, Held U, Ickstadt K, Heinz M, Schach S, Ebers G: Reducing the Probability of false positive Research Findings by pre-publication Validation Experience with a large Multiple Sclerosis Database. BMC Medical Research Methodology 8:18, 2008
" Schunkert, H. et al. for the Cardiogenics Consortium: Repeated Replication and a Prospective Meta-Analysis of the Association Between Chromosome 9p21.3 and Coronary Artery Disease. Circulation 117, 1675-1684, 2008
" Daumer M, Scholz M, Boulesteix AL, Pildner von Steinburg S, Schiermeier S, Hatzmann W, Schneider KTM: The Normal Fetal Heart Rate Study: Analysis Plan , Available at Nature Precedings http://precedings.nature.com/documents/980/version/2, 2007
" Daumer M., Neuhaus A., Lederer C., Scholz M., Wolinsky JS and Heiderhoff M.: Prognosis of the individual course of disease steps in developing a decision support tool for Multiple Sclerosis. BMC Medical Informatics and Decision Making 2007, 7:11
" Daumer M, Thaler K, Kruis E, Feneberg W, Staude G, Scholz M: Steps towards a miniaturized, robust and autonomous measurement device for the long-term monitoring of the activity of patients ActiBelt . Biomedizinische Technik, Biomedical Engineering 52: 149-55, 2007
" Noseworthy J., Kappos L., Daumer M.: Competing interests in Multiple Sclerosis research , The Lancet 361, S. 350f, 2003
" Daumer M.: Online Monitoring von Changepoints in: Biomedizinische Technik, 42, Ergänzungsband 2, Verlag Schiele und Schön, S. 214-215, 1998
" Daumer M., Nahm W., Scholz M., Dannegger F., Kochs E., Morfill G.: Konzept für eine internet-basierte Datenbank zur Unterstützung von Projekten in der Biosignalanalyse , Ergänzungsband Biomed Tech, 43 (3), S. 23-27, 1998

Responsible for Module:
Diepold, Klaus; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Clinical Applications of Computational Medicine (lecture, 2 SWS)
Daumer M (Hausamann P)

For further information in this module, please click
campus.tum.de or here.

Specialization in Technology: Power Engineering (major)

Technische Universität München

Module Description

EI0610: Electrical Drives - Fundamentals and Applications

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In einer schriftlichen Abschlussklausur (90 min) ohne Hilfsmittel weisen die Studierenden durch das Beantworten von Wissensfragen und Rechnungen, dass sie die Aufbau und Einbettung von Antrieben in übergeordnete Systeme verstanden haben. Daneben weisen sie die Fähigkeit beispielsweise zur korrekten Berechnung von Parametern wie Auslegung und Diemensonierung nach.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Differentialgleichungen, komplexe Wechselstromrechnung, Maxwell-Gleichungen, Lorentz-Kraft, Regelungstechnik

Folgende Module sollten vor der Teilnahme bereits erfolgreich absolviert sein:
- Mathematik 1 bis 4
- Elektrizität und Magnetismus
- Systeme

Content:
Geregelte elektrische Antriebe: Grundsätzliche Struktur, Verhalten im anzutreibenden System, Komponenten und deren Eigenschaften (elektrische Maschine, Stromrichter und deren Steuerung bzw. Regelung), Zusammenwirken der Komponenten, Auswirkung von digitalen Reglern, Normen und Richtlinien (CE-Kennzeichnung)

Intended Learning Outcomes:
Nach dem erfolgreichen Abschluss des Moduls kennt der Studierende den grundsätzlichen Aufbau sowie das Verhalten von geregelten Antrieben und ist in der Lage, die Wechselwirkungen zwischen ihren Bestandteilen sowie mit übergeordneten Systemen zu erkennen, einzuschätzen und zu berechnen. Er hat die Fähigkeit, elektrische Antriebe sowie deren Komponenten in realen Anwendungen grob auszulegen. Der Studierende hat vertiefte Kenntnis und Verständnis der elektromagnetischen Drehmomenterzeugung und Spanungsinduktion, und Verständnis der Hintergründe und Ziele der CE-Kennzeichnung sowie deren Konsequenzen für geregelte elektrische Antriebe.

Teaching and Learning Methods:
AIn den Vorlesungen wird Frontalunterricht gehalten. In den Übungen erfolgt die selbsständige Befassug der Studierenden mit den Themen des Moduls zum Kompetenzerwerb (Aufgaben rechnen, vertiefende Herleitungen und Simulationsbeispiele).

Media:
Folgende Medienformen finden Verwendung:
- Präsentationen (Overhead und PowerPoint)
- Skript
- Übungsaufgaben und Lösungsfolien als Download im Internet

Reading List:
Folgende Literatur wird empfohlen:
- Schröder, D. "Elektrische Antriebe-Grundlagen", 3. Auflage 2007, Springer Verlag, Hamburg
- Brosch, F. "Moderne Stromrichterantriebe", 4. Auflage, 2002, Vogel Verlag und Druck
- Mohan, N. Electric Drives: An integrative approach , MNPERE, Minneapolis, USA, 2001
- Groß, H. et al. "Elektrische Vorschubantriebe in der Automatisierungstechnik", 1. Auflage, Publicis Corporate Publishing, 2000

Responsible for Module:
Kennel, Ralph; Prof. Dr.-Ing. Dr. h.c.

Courses (Type of course, Weekly hours per semester), Instructor:
Electrical Actuators (lecture with integrated exercises, 3 SWS)
Kennel R [L], Kennel R (Ebert W), Klaß S

For further information in this module, please click
campus.tum.de or here.

Module Description

EI0611: Basics of Electrical Energy Storage

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Im Rahmen einer 60 minütigen schriftlichen Klausur wird durch das Beantworten von Fragen und Berechnungen an vorgegebenen Speichersystemen überprüft, ob die Studierenden in der Lage sind Speichertechnologien wiederzugeben und anhand eines universellen Speichermodells zu beschreiben.

Während des Semesters sollen fachliche Vertiefungen durch Lesen von Fachartikeln erfolgen. Diese zu lesenden Artikel werden in der Vorlesung diskutiert und sind auch prüfungsrelevant.

Die Endnote setzt sich aus folgenden Prüfungselementen zusammen:
- 100 % Abschlussklausur

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Keine speziellen Anforderungen

Content:
Die Vorlesung vermittelt einen Einblick in die Grundlagen und die Funktionsweise von elektrischen Energiespeichern.
- Einführung, Begriffe, Definitionen
- Abstraktes Speichermodell
- Grundlagen kinetische Speicher (Schwungrad)
- Grundlagen weitere mechanische Speicher (Druckluft, Pumpspeichersystem)
- Grundlagen direkte elektrische Speicher
- Grundlagen Batteriespeicher
- Grundlagen Gasspeicher (Elektrolyse, Methanisierung ...)

Intended Learning Outcomes:
Nach erfolgreichem Abschluss des Moduls ist der Hörer in der Lage unterschiedlichen Speichertechnologien und darauf basierende Speichersysteme zu berechnen und zu bewerten, einschließlich eventueller Wandlersysteme, die notwendig sind. Anhand einer abstrakten Betrachtung mit einem universellen Speichermodell vermögen sie eine technologieunabhängige Betrachtung einzusetzen.

Teaching and Learning Methods:
Als Lehrmethode wird in der Vorlesung Frontalunterricht, ergänzt durch Gruppendiskussionen, verwendet. Ferner sollen Exponate zur Veranschaulichung eingesetzt werden und einige Zusammenhänge werde auch mittels Animationen gezeigt.

Als Lernmethode wird zusätzlich zu den individuellen Methoden des Studierenden eine vertiefende Wissensbildung durch anschauliche Fallstudienbetrachtungen angestrebt.

Media:
Folgende Medienformen finden Verwendung:
- Präsentationen mit Laptop und Beamer
- Tafelanschrieb
- Diskussionen zu Fachaufsätzen und aktuellen Themen, wie Speicher in der Elektromobilität und Speicher für die Enmergiewende.

Reading List:
Allgemeine Literatur wird in der Vorlesung bekannt gegeben.
Es werden verschiednene Zeitschriftenbeiträge online zur verfügung gestellt, die dann auch in der Vorlesung diskutiert werden.

Responsible for Module:
Jossen, Andreas; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Basics of Electrical Energy Storage (lecture, 3 SWS)
Jossen A, Kucevic D

Basics of Electrical Energy Storage (exercise, 1 SWS)
Jossen A, Kucevic D

For further information in this module, please click
campus.tum.de or here.

Module Description

EI0620: Fundamentals of Electrical Machines

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Anhand von Kurzfragen und Berechnungen bezüglich der Wirkungsweise und des Aufbaus elektreischer Maschinen weisen die Studierenden in einer Abschlussklausur (90 min) ohne Hilfsmittel nach, dass sie die Grundlagen elektrischer Maschinen verstanden haben und die zugehörigen Betriebskennlinien korrekt anwenden können.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Grundkenntnisse über elektromagnetische Felder und elektrische Energietechnik, Maxwell-Gleichungen, komplexe Rechnung.

Folgende Module sollten vor der Teilnahme bereits erfolgreich absolviert sein:
- Elektromagnetische Feldtheorie
- Elektrische Energietechnik

Content:
Achshöhen und Bauformen elektrischer Maschinen; Grundlagen:
eindimensionale Feldberechnung in elektrischen Maschinen, Kraft- und Drehmomententstehung, thermisches Punktmassenmodell; quasi-stationäres Betriebsverhalten elektrischer Maschinen (jeweils unter Vernachlässigung des Primärwiderstands): elektrisch erregte Gleichstrommaschine, Drehfeld-Asynchronmaschine mit Käfigläufer, elektrisch erregte Drehfeld-Synchronmaschine mit Vollpolläufer; Drehstrom-Transformator; Berücksichtigung von Permanentmagneten: permanenterregte Gleichstrommaschine.

Intended Learning Outcomes:
Nach erfolgreichem Abschluss des Moduls verstehen die Studierenden die physikalische Wirkungsweise sowie die Drehmomententstehung in elektromechanischen Wandlern. Die Studierenden kennen den grundlegenden Aufbau sowie die Funktionsweise elektrischer Maschinen.
Darüber hinaus kennen die Studierenden das quasi-stationäre Betriebsverhalten der Maschinentypen, sie verstehen die zugehörigen Betriebskennlinien und können sie anwenden.

Teaching and Learning Methods:
Als Lernmethode wird zusätzlich zu den individuellen Methoden der Studierenden eine vertiefende Wissensbildung durch mehrmaliges Aufgabenrechnen in Übungen angestrebt.

Als Lehrmethode wird in den Vorlesungen und Übungen Frontalunterricht gehalten, in den Übungen auch Arbeitsunterricht (Aufgaben rechnen).

Media:
Folgende Medienformen finden Verwendung:
- Präsentationen
- Skript
- Übungsaufgaben mit Lösungen als Download im Internet

Reading List:
Folgende Literatur wird empfohlen:
- R. Fischer, Elektrische Maschinen, Hanser-Verlag

Responsible for Module:
Herzog, Hans-Georg; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Basics of electrical machines (lecture with integrated exercises, 4 SWS)
Filusch D [L], Herzog H, Filusch D

For further information in this module, please click
campus.tum.de or here.

Module Description

EI1287: Laboratory Course Power Transmission and High Voltage Technology

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Master	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	115	35

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsleistung wird in drei verschiedenen Formen erbracht.
Im Eingangstest zu jedem Praktikumsversuch (ohne Hilfsmittel) werden die theoretischen Grundlagen zu den jeweiligen Versuchen aus dem Selbststudium der Skripten/Versuchsunterlagen abgefragt. Die Studierenden zeigen damit, dass sie in der Lage sind, den darauffolgenden Versuch korrekt und eigenständig durchzuführen.
Die benotete Versuchsdurchführung jedes Praktikumsversuches dient dem Nachweis, dass die Studierenden die zuvor erlernten theoretischen Grundlagen praktisch anwenden können. Insbesondere die Berechnung und Interpretation der jeweiligen Kenngrößen wird geprüft.
Die schriftliche Ausarbeitung eines Praktikumsversuchs dient der Überprüfung, ob das vorher theoretisch erlernte und praktisch angewandte Wissen tiefer verstanden wurde.

Die Abschlussnote ergibt sich aus der gewichteten Bewertung der Eingangstests, der schriftlichen Dokumentation sowie der mündlichen Mitarbeitsnote (Eingangstest 20%, benotete Versuchsdurchführung 40%, schriftliche Ausarbeitung 40%)

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Kenntnis grundlegender Vorgänge in der Energieübetragungstechnik (Verhalten von Betriebsmitteln wie z.B. Transformatoren und Übertragungsleitungen) sowie der Hochspannungstechnik, wie sie in der thematisch abgestimmten Vorlesung Energieübertragungs- und Hochspannungstechnik (EI1291) vermittelt werden. Hinweis: Für ein erfolgreiches Absolvieren des Parktikums wird ein vorheriges Ablegen der zugehörigen Vorlesung dringendst empfohlen.

Content:
Das Praktikum besteht aus 5 Versuchen zu folgenden Themen:
- Messen hoher Spannungen
- Verhalten von Luftfunkenstrecken
- Transformator und Leitung
- Leitungsschutz
- Wanderwellen

Intended Learning Outcomes:
Nach Teilnahme am Praktikum hat der Studierende sein Verständnis für die grundlegenden Mechanismen des elektrischen Durchschlags, die Erzeugung und Messung hoher Spannungen, Vorgänge in Transformatoren und Leitungen, sowie Grundlagen der Netzschutztechnik durch praktische Versuche vertieft.

Teaching and Learning Methods:
Die theoretischen Grundlagen werden in Form von kurzen Skripten oder als Verweis auf die entsprechende Literatur zur Verfügung gestellt. Die Aufgaben- / Hilfestellungen werden in digitaler Form bereitgestellt. Durch das Führen eines Versuchsprotokolls werden die im Praktikum behandelten Themen vertieft. Die Versuchsbetreuung erfolgt durch wissenschaftliche Mitarbeiter

Die praktische Anwendung der theoretischen Grundlagen erfolgt im Rahmen von Experimenten (in Gruppenarbeit).

Media:
- Sicherheitsunterweisung
- Versuchsanleitung (inkl. Theorieteil) zu jedem Versuch
- Versuchsstände im Labor

Reading List:
D. Kind, K. Feser: Hochspannungs-Versuchstechnik

K. Heuck, K.-D. Dettmann, D. Schulz: Elektrische Energieversorgung

D. Oeding, B.R. Oswald: Elektrische Kraftwerke und Netze

A. J. Schwab: Elekto-Energiesysteme

Responsible for Module:
Rolf Witzmann (rolf.witzmann@tum.de)

Courses (Type of course, Weekly hours per semester), Instructor:
Praktikum Energieübertragungs- und Hochspannungstechnik (3 SWS)

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

EI1291: Transmission of Electrical Energy - High Voltage Engineering

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfung besteht aus einer schriftlichen Klausur (60 min), in der die Studierenden die vermittelten Themen der Hochspannungs- und Energieübertragungstechnik ohne Hilfsmittel abrufen und wiedergeben sollen. Die Beantwortung der Fragen erfordern teils eigene Formulierungen und teils einfache Berechnungen.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Grundkenntnisse der elektrischen Energietechnik

Content:
Hochspannungsprüftechnik, Elektrostatisches Feld, Elektrische Isolierstoffe, Überspannungen und Isolationsbemessung, Übertragungs- und Verteilnetze, Gewitterelektrizität und Blitzschutz

Intended Learning Outcomes:
Nach der Teilnahme an den Modulveranstaltungen ist der Studierende in der Lage, die Grundzüge der elektrischen Energieübertragung und der Hochspannungstechnik zu verstehen. Er kennt die gängigen Prüfanlagen zur Erzeugung hoher Gleich-, Wechsel- und Stossspannungen sowie die notwendige Prüftechnik. Er kennt die Grundzüge der Elektrostatischen Feldverteilung und ihre Bedeutung für die Isolation. Das grundlegende Verhalten von festen,flüssigen und gasförmigen Isolierstoffen hinsichtlich Isolation und Durchschlagsverhalten ist den Studierenden bekannt. Die Entstehung und Auswirkungen von äußeren und inneren Überspannungen in Hochspannungs-Energieübertragungssystemen werden vermittelt.
Die Studierenden erhalten Einblick in unsere Energieversorgungssysteme, deren Funktionsweise und deren grundlegende Komponenten, wie zum Beispiel Transformator und Leitung.

Teaching and Learning Methods:
Als Lernmethode wird zusätzlich zu den individuellen Methoden des Studierenden eine vertiefende Wissensbildung durch mehrmaliges Aufgabenrechnen in Übungen angestrebt.

Als Lehrmethode wird in der Vorlesungen Frontalunterricht, in den Übungen Arbeitsunterricht (Aufgaben rechnen) gehalten.

Media:
Folgende Medienformen finden Verwendung:
Folienvortrag, Skriptum, Übungen

Reading List:
Beyer, M.; Boeck, W.; Möller, K.; Zaengl, W.: Hochspannungstechnik: theoretische und praktische Grundlagen. Berlin, Heidelberg Springer 1986;
Kind, D.; Feser, K.: Hochspannungsversuchstechnik. Braunschweig Vieweg 1995;
Kind, D.; Kärner, H.: Hochspannungs-Isoliertechnik für Elektrotechniker. Braunschweig: Vieweg-Verlag, 1987;
Oeding, D.; Oswald, B. R.: Elektrische Kraftwerke und Netze. Berlin: Springer-Verlag, 6. Aufl., 2004;
Hosemann, G.; Boeck, W.: Grundlagen der elektrischen Energietechnik (4. Aufl.). Berlin: Springer Verlag 1991

Responsible for Module:
Rolf Witzmann

Courses (Type of course, Weekly hours per semester), Instructor:
Power transmission and high voltage technology (exercise, 1 SWS)
Przibylla J [L], Aigner C

Power transmission and high voltage technology (LB/DBP/TUM BWL) (lecture, 2 SWS)
Przibylla J [L], Witzmann R

For further information in this module, please click
campus.tum.de or here.

Module Description

EI70810: Battery Storage [BAT]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Anhand einer schriftlichen Prüfung (60 min) ohne Unterlagen ohne Hilfsmittel weisen die Studierenden nach, dass sie elektrochemische Zusämmenhänge von Batteriezellen abrufen und erinnern können. Das Beantworten der Fragen erfordert teils eigene Formulierungen und teils kurze Berechnungen.

Während des Semesters sollen fachliche Vertiefungen durch Lesen von Fachartikeln erfolgen. Diesezu lsenden Artikel werden in der Vorlesung diskutiert und sind auch prüfungsrelevant.

Die Endnote setzt sich aus folgenden Prüfungselementen zusammen:
- 100 % Abschlussklausur

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Keine speziellen Anforderungen

Content:
Die Vorlesung vermittelt einen Einblick in die Grundlagen und die Funktionsweise von Batteriespeichen. Der Schwerpunkt liegt hierbei bei wiederaufladbaren Systemen, wie sie in mobilen Geräten, Elektrofahrzeugen und photovoltaischen Inselsystemen eingesetzt werden.
- Einführung, Begriffe, Definitionen
- Einführung in die Elektrochemie
- Thermodynamische Grundlagen (Gleichgewichtszustand)
- Kinetik und Überspannungen (Spannungszusammensetzung unter Stromfluss)
- Die elektrochemische Doppelschicht
- Diffusionsvorgänge und Vor- nachgelagerte Reaktionen
- Aufbau einer Zelle (unterschiedliche Konstruktionsprinzipien)
- Optimierung von Batterien für unterschiedliche Anforderungen
- Doppelschichtkondensatoren (ideales und reales Verhalten)
- Bleibatterien,
- Alkalische Systeme,
- Li-Ionen Systeme und zukünftige Li-Systeme
- Redox flow und Hochtemperatursysteme

Intended Learning Outcomes:
Die Teilnehmer haben nach dem erfolgreichen Abschluss des Moduls grundlegende Kenntnisse zum elektrochemischer Speicher. Das umfasst die grundlegenden elektrochemischen Zusammenhänge, die Methodik zum Charakterisieren und Auslegen von Speichersystemen. Sie sind in der Lage diese Fragestellungen am Beispiel aktueller Anwendungen, wie der Elektromobilität, diese Aspekte selbständig auch auf andere Anwendungsbereich zu übertragen. Durch das gelegentliche kritische Lesen und Diskutieren von Fachaufsätzen wird an das wissenschaftliche Arbeiten herangeführt.

Teaching and Learning Methods:
Als Lehrmethode wird in der Vorlesung Frontalunterricht, ergänzt durch Gruppendiskussionen, verwendet. Ferner sollen Exponate zur Veranschaulichung eingesetzt werden und einige Zusammenhänge werde auch mittels Animationen gezeigt.

Als Lernmethode wird zusätzlich zu den individuellen Methoden des Studierenden eine vertiefende Wissensbildung durch anschauliche Fallstudienbetrachtungen angestrebt.

Media:
Folgende Medienformen finden Verwendung:
- Präsentationen mit Laptop und Beamer
- Tafelanschrieb
- Diskussionen zu Fachaufsätzen und aktuellen Themen, wie Speicher in der Elektromobilität und Speicher für die Energiewende.

Reading List:
Allgemeine Literatur wird in der Vorlesung bekannt gegeben.
Es werden verschiedene Zeitschriftenbeiträge online zur Verfügung gestellt, die dann auch in der Vorlesung diskutiert werden.

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click
campus.tum.de or here.

Specialization in Technology: Computer Engineering (minor)

Module Description

EI10001: Principles of Information Engineering [PIE]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	135	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module examination is based on a written exam (75 minutes) which contains questions to asses the students' knowledge about the technical systems, e.g. information transmission systems, and their theoretical background, e.g. design priciples, short mathematical problems to assess the students' mastering of the practiced mathematical concepts, and conceptual questions (e.g., about design principles or fundamental limitations) to assess the further intended learning outcomes. Up to 20% of the examination can be conducted in the form of multiple choice questions.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
The following module should be successfully completed prior to participation: MA9711 Mathematics in Natural and Economic Science 1.
The following module is recommended to be attended in parallel (if not already attended earlier): MA9712 Statistics for BWL.

Content:
* Fundamentals:
- Elements of Stochastic Modeling and Analysis
- Signals (analog/digital, deterministic/stochastic, real/complex)
- The Frequency Domain (Fourier transform, spectrum and bandwidth, sampling theorem)
- Information Theory (fundamentals, source coding, channel coding, channel capacity)
* Information Transmission and Storage Systems:
- Elements of Data Transmission (transmission chain, filtering, modulation, detection)
- Communication Systems (real systems compared to theory, channel models, performance criteria, comparison to data storage, current trends)
- Communication Networks (network structures, interference, broadcast and multiple access, multihop and relaying, abstraction layers, network planning)
* Elements of Information Processing
- Data Processing Devices (abstraction layers, real systems compared to theory, digital processing, algorithms and complexity)
- Data Acquisition and Analysis (sampling and quantization, information and noise modeling, feature extraction, machine learning)
- Security Aspects (reliability, security, secrecy, encryption)

Intended Learning Outcomes:
After attending the module, the students:
- can describe the main principles of operation of information transmission systems and networks as well as of data processing devices and methods
- are familiar with fundamental design principles of such systems and understand why existing systems are designed the way they are
- have an overview of the underlying physical and mathematical principles and can distinguish fundamental limitations from technological constraints
- have learned to take an engineering perspective on information transmission and processing tasks (e.g., by structuring a system into building blocks and abstraction layers)
- know the main mathematical methods relevant for this field of engineering and are able to apply a selection of these methods to example problems

Teaching and Learning Methods:
The module is designed for non-engineering students (in particular students in Management and Technology) who aim at understanding the fundamental principles and concepts of modern information transmission and processing. It consists of lectures, tutorials, and self-study.

In the lectures, both theoretical backgrounds and technical implementations are introduced and discussed. Mathematical concepts are introduced and explained as far as it is necessary for understanding the technical systems. The relevance of each of the considered topics is motivated by, e.g., press articles, teaser questions, or examples from daily life, and an additional reflexion at the end of each topic unit aims at conveying the engineering perspective on the considered problems and systems. New concepts are presented in a teacher-centered style and discussed in an interactive manner.

The aim of the tutorials is to repeatedly practice the application of the mathematical concepts as well as the ability to answer conceptual questions about the subject. The tutorials are held in a student-centered way, and problem sheets are provided.

Throughout the semester, short reading assignments may be given to the students, e.g., as an introduction to a new topic. In addition, the students are expected to recapitulate the lecture contents and to individually practice the exercises.

Media:
- Slide Presentations
- Blackboard (e.g., for mathematical details)
- Supporting documents (e.g., news articles, scientific publications) as downloads (reading assignments)
- Problem sheets as downloads

Reading List:
Recommendations and downloads are provided during the course separately for each topic.

Responsible for Module:
Utschick, Wolfgang; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click
campus.tum.de or here.

Module Description

EI10002: Principles of Electrotechnology [PiET]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
This module will be assessed in a written final examination (90 min) after the teaching weeks. In this examination it is to verify that the candidates are able to understand the general principles of electrical engineering and to solve relevant problems in the fields covered in this module in a limited time and without any resources. The examination will cover all parts of the lectures and exercises.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge of electricity and magnetism on high school level.
Basic knowledge of vector analysis.

Content:
Electrostatics:
Electrical charges, Coulomb's law, electrostatic fields, electrostatic potentials and voltages.

Dielectric materials:
Polarisation, dielectric displacement vector, Gauß' law, capacitors and capacitances.

Stationary electrical currents:
Current densities, local and integral Ohm's law, Kirchhoff's laws, resistors and resistivities, electrical networks, voltage and current sources, equivalent circuits, electrical energy and power.

(Electro-)magnetism:
Fundamental terms in magnetism, magnetic dipoles, Dia-, Para-, Ferromagnetism, magnetising field, magnetic induction, Amperé's law, electromagnetic induction, Faraday's law, inductors and inductivities, transformers.

Intended Learning Outcomes:
After participating in the modules lectures and exercises, students are able to understand and apply the basic physical principles of electrical engineering. They have acquired basic knowledge and understanding of some of the underlying problem-solving methods of electrical engineering.

Teaching and Learning Methods:
Teaching methods in lectures and exercises: Lecture-style instructions mainly on the blackboard.
In solving relevant exercises a deeper knowledge of the subject-matters presented in the lectures is sought.

Media:
The following media types are used in the lectures and exercises:
- Explanations and exemplifications on the black board, partly supplemented by computer-aided presentations.
- Downloads on the Internet.
- Exercises are provided with the objective that the students first should solve the problems independent by themselves, solution to the problems will be demonstrated in subsequent exercise sessions, and subsequently will be made available also via download on the Internet.

Reading List:
References will be presented in the first lecture hour.

Responsible for Module:
Schrag, Gabriele; Prof. Dr. rer. nat. habil.

Courses (Type of course, Weekly hours per semester), Instructor:
Principles in Electrotechnology (lecture, 3 SWS)
Wittmann F

Principles in Electrotechnology (exercise, 1 SWS)
Wittmann F [L], Hölzl W (Eßing S)

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

EI10003: Analog Electronics [AE]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	100	50

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
This module will be assessed in a written final examination (90 min) after the teaching weeks. In this examination it is to verify that the candidates are able to understand the general principles of analog electronic circuits and to solve simple but relevant problems in the fields covered in this module in a limited time and without any resources. The examination will cover all parts of the lectures and exercises of this module.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Subject matters as presented in the module "Principle of Electrotechnology"
Calculus; complex numbers and operations for ac signal analysis

Content:
Electronic signals
Circuit analysis (dc, ac)
Electrical characteristics of electronic devices
Electronic filters
Basics of semiconductor¿s physics
PN Junctions, pn diodes
Transistors
Basic Transistor circuits
Amplifiers

Intended Learning Outcomes:
After participating in the modules lectures and excercises, students are able to
- understand and apply the basic principles of analog electronic cicuits
- have acquired basic knowledge and understanding of some of the basic problem-solving methods of electronic cicuits.

Teaching and Learning Methods:
Teaching methods in the lectures and excercises: frontal teaching with presentations and on the blackboard.
In solving relevant exercises a deeper knowledge of the subject matters of the lessons is sought.

Media:
The following media types are used in the lectures and excercises:
- Presentations (also for downloads on the Internet)

- Explanations and exemplifications on the black board
- Exercises are provided with the objective that the students first should solve the problems independent by themselves, the solutions to the problems will be demonstrated in subsequent excercise sessions, and subsequently will be made available also via download on the Internet.

Reading List:

Responsible for Module:
Schrag, Gabriele; Prof. Dr. rer. nat. habil.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

EI5183: Control Theory (MSE)

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
4	120	75	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination consists of a single written test at the end of the semester. The written examination is with closed book policy and no supporting material is allowed during the test. It consists of questions to determine the students' understanding of various concepts, e.g., Cayley-Hamilton theorem, singular value decomposition, stability, Lyapunov equations, controllability, observability, realization theory, state feedback, and state observers. The final exam is a written one that includes calculations, e.g. regarding the design of controlers, and its duration is 90 minutes.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge of differential equations and linear algebra are necessary.

Content:
Mathematical description of systems: state-space representations, existence and uniqueness theorems for ODEs, solutions of linear ODEs, matrix exponential, input-output description of continuous-time systems, transfer functions; Analysis of linear systems: stability, Lyapunov equations, controllability, observability; Realizations: realization theory, balanced realizations, minimum energy inputs, coprime fractions; Design of linear systems: state feedback, state observers, separation property, pole placement, tracking and disturbance rejection;

Intended Learning Outcomes:
Upon successful completion of the module, students are able to understand modeling of dynamical systems and their representations. They are able to analyse the model, its stability, controllability, and observability. Finally, they are able to design controllers enforcing some performance criteirion on the model.

Teaching and Learning Methods:
Lecture is designed as an interactive session. The materials are covered step by step from skratch under the participation of the students. Several examples are exercised during each session with hand calculations on the blackboard so that students can deeply understand the covered materials.

Media:
Black board
(Possibly) Lecture Notes
Exercises with solutions as download

Reading List:
1- P. J. Antsaklis and A. N. Michel: A Linear Systems Primer, Springer, 2007. 2- C. T. Chen: Linear System Theory and Design, Oxford University Press, 4th edition, 2012.

Responsible for Module:
Chakraborty, Samarjit; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click
campus.tum.de or here.

Module Description

IN2113: Programming Languages

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor/Master	German/English	one semester	irregularly
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The assessment is by means of a written exam of 90 minutes. Individual assignments assess in how far students are able to reproduce the complex semantical behaviors small example programs. Their knowledge and practical skills concerning programming constructs is further assessed by assignments which ask to simulate programming language constructs of one kind by programming language constructs of another kind. The successful 15-minute presentation of a further topic related to the lecture may contribute to the grad as a 0.3 bonus.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
IN0001 Introduction to Informatics 1, IN0002 Fundamentals of Programming (Exercises AAA Laboratory), IN0003 Introduction to Informatics 2, at least one programming language.

Content:
This lecture provides background information on various programming language concepts as they are provided in popular programming languages. Topics may include, among others:
- Generics
- Types
- Inheritance and delegation
- Garbage collection
- concurrency
- Meta programming

Intended Learning Outcomes:
Participants know about the various progamming language constructs and their meanings. They are able to compare different language based approaches, to discuss their relative merits and potential work-arounds, if particular language features are missing.

Teaching and Learning Methods:
By means of a presentation, either by slides or whiteboard, the lecture presents fundamental concepts of programming languages and illustrates these by means of small examples. Accompanying assignments for individual study deepen the understanding of the concepts explained in the lecture, train students to apply the learnt concepts in implementations and develop the skill to to simulate the effect of missing language features by others.

Media:
Slide show, blackboard, online programming experiments, animations, lecture recording

Reading List:
Selected literature of the area and appropriate conference or journal papers

Responsible for Module:
Seidl, Helmut; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Exercise - Programming Languages (IN2113) (exercise, 2 SWS)
Löbel R

Programming Languages (IN2113) (lecture, 2 SWS)
Petter M

For further information in this module, please click
campus.tum.de or here.

Module Description

IN8005: Introduction into Computer Science (for non Informatics studies)

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Type of Assessment: written exam (90 minutes)
The exam takes the form of written test. Knowledge questions allow to assess acquaintance with and understanding of the basic concepts of Computer Science. Small programming and modelling problems allow to assess the ability to practically apply the learned programming- and query-languages and modelling-techniques for the solution of small problems.
Homework will be scored and upon achieving a minimum equired number of points, a 0,3 bonus for the final grade is granted.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Recommended requirements are Mathematics modules of the first year of the TUM-BWL bachelor's program as well as the module WI000275 'Management Science'.

Content:
The module IN8005 is concerned with topics such as:
- Database Management Systems,.ER models, Relational Algebra, SQL
- Java as a programming language:
  ++ basic constructs of imperative programming (if, while, for, arrays etc.)
  ++ object-oriented programming (inheritance, interfaces, polymorphism etc.)
  ++ basics of Exception Handling and Generics
  ++ code conventions
  ++ Java class library
- Basics of Visual Basic for Applications
- Basic algorithms and data structures:
  ++ algorithm concept, complexity
  ++ data structures for sequences (arrays, doubly linked lists, stacks & queues)
  ++ recursion
  ++ hashing (chaining, probing)
  ++ searching (binary search, balanced search trees)
  ++ sorting (Insertion-Sort, Selection-Sort, Merge-Sort)

Intended Learning Outcomes:
Upon successful completion of the module, participants understand important foundations, concepts and ways of thinking of Computer Science, in particular object-oriented programming, databases and SQL, and basic algorithms and data structures, have an overview over these topics and be able use them for the development of

own programs with a link to a database in a basic way.

Teaching and Learning Methods:
Lecture and practical tutorial assignments. A central tutorial deepens the understanding of the concepts introduced in the lecture using example assignments in regard to being able to solve given problems. In the tutorials, the students solve basic assignments under intensive supervision, which contributes to providing them with the basic skills in programming, in order to be able to apply the knowledge acquired by self-study of the accompanying materials of lecture and central tutorial for autonomously solving the programming assignments of the homework. During the second half of the semester, the students work on a small practical project, which aims at deepening the connected understanding of the desired learning outcomes. Programming aspects of this project are distributed over tutorial and homework assignments and are aligned with the topics of the respective week.

Media:
Slides, blackboard, lecture- and central tutorial recording, discussion boards in suitable e-learning platforms

Reading List:
Chapters from textbooks, which are closely associated with the module content and are provided to the students online.

Responsible for Module:
Seidl, Helmut; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Introduction into Computer Science (for non Informatics studies, TUM BWL) (IN8005) (lecture, 2 SWS)
Groh G

Exercise Session for Introduction into Computer Science (for non Informatics studies, TUM BWL) (IN8005) (exercise, 2 SWS)
Groh G [L], Dall'Olio G, Groh G, Steinberger C

For further information in this module, please click
campus.tum.de or here.

Specialization in Technology: Computer Engineering (major)

Module Description

EI04007: Real-Time and Embedded Systems 1 [RTES1]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	105	75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the written examination (90 min), students answer questions under time pressure and without any helping material except for a non-programmable calculator. Answering the questions requires both own formulations but also selecting the correct answer among given suggestions. Some questions require the application of calculation techniques where the students demonstrate that they have gained deeper knowledge of design principles, timing, cache modeling, worst case execution time analysis, system level timing analysis and formal modeling and verification techniques.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic principles of Computer Architecture, Programming in C/C++

Content:
We will study different design issues for embedded and real-time systems. Students will learn how to perform high-level timing analysis of embedded systems. We will study aspects to be taken into account when calculating best and worst case execution times of embedded program code. Towards this it is important to understand basic processor architecture concepts. We will learn different scheduling techniques in multiprocessor architectures where different processors are connected by buses and multiple tasks are mapped onto processors. Finally, we discuss formal models for systems design on a high level of abstraction and we see how these models can be used to prove that a system behaves correctly.

Intended Learning Outcomes:
At the end of the module, students are able

- to apply various design principles to industrial problems
- to analyze the performance and timing of simple embedded processor architectures
- to apply worst case execution time analysis of embedded programs
- to apply system level timing analysis and scheduling techniques
- to understand formal modeling and verification techniques

Teaching and Learning Methods:
The lectures help the students to understand and connect the learning outcomes. During the lectures students are instructed in a teacher-centered style. In addition to the individual methods of the students, consolidated knowledge is aspired by repeated lessons in exercises. The exercises help the students to transfer their knowledge

and to apply it to solve typical problems. The exercises are held in a student-centered way.

Media:
Presentations
Lecture Notes
Exercises with solutions as download

Reading List:
Wayne Wolf, High-Performance Embedded Computing -
Morgan Kaufmann Publishers, 2007

Jane W. S. Liu, Real-Time Systems, Prentice Hall, 2000

Slides and handouts will be provided in Moodle. Further reading material is recommended during the lecture.

Responsible for Module:
Chakraborty, Samarjit; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Real-Time and Embedded Systems 1 [Lecture] (lecture, 3 SWS)
Pröbstl A, Balszun M

Real-Time and Embedded Systems 1 [Exercise] (exercise, 2 SWS)
Pröbstl A, Balszun M

For further information in this module, please click
campus.tum.de or here.

Module Description

EI04008: Real-Time and Embedded Systems 2 [RTES2]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	105	75

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the written examination (90 min), students answer questions on their gained theoretical knowledge under time pressure and without any helping material except for a non-programmable calculator. Answering the questions requires both own formulations but also selecting the correct answer among given suggestions. Some questions require the application of calculation techniques. The students demonstrate that they are capable to find solutions for concrete problems in multiprocessor systems and required communication infrastructure. They examination tests their knowledge on power management problems, formal specification techniques, real-time operating systems and design space exploration.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Real-time and Embedded Systems 1, Basic principles of Computer Architecture, Programming in C/C++

Content:
In this course, we will study further design aspects for real-time and embedded systems. Formal specifications of a systems can help to formally verify the correctness of systems. We will study one example of a formal specification technique: Esterel. We then study connection techniques for multiprocessor architectures and arbitration techniques for their communication medium. This plays an important role in networked control systems. Next, we will discuss aspects of real-time operating systems. We also cover their benefits and problems. As battery run-time is one of the primary design constraints, we will discuss power management aspects in embedded systems. Finally, we learn techniques to perform design space exploration of the architecture design space.

Intended Learning Outcomes:
At the end of the module, students are able

- to apply techniques to generate code from formal verifications
- to analyze techniques for connecting multiple processors
- to apply arbitration techniques for communication media
- to characterize real-time operating systems
- to investigate power management techniques for embedded systems
- to conduct design space exploration for embedded system design

Teaching and Learning Methods:
The lectures help the students to understand and connect the learning outcomes. During the lectures students are instructed in a teacher-centered style. In addition to the individual methods of the students, consolidated

knowledge is aspired by repeated lessons in exercises. The exercises help the students to transfer their knowledge and to apply it to solve typical problems. The exercises are held in a student-centered way.

Media:
Presentations
Lecture Notes
Exercises with solutions as download

Reading List:
Wayne Wolf, High-Performance Embedded Computing -
Morgan Kaufmann Publishers, 2007
Jane W. S. Liu, Real-Time Systems, Prentice Hall, 2000
The slides and handouts are available on moodle and further reading material is recommended during the lecture.

Responsible for Module:
Chakraborty, Samarjit; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

Samarjit Chakraborty (samarjit@tum.de)

For further information in this module, please click
campus.tum.de or here.

Module Description

EI0697: Mobile Communications

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Bachelor	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
For succesful participation in the lecture, the student has to pass a written exam (90 min). The overall grade will be solely based on the student's result in the written exam. Students will demonstrate that they have gained both fundamental and deeper understanding in various aspects of mobile communications. They have to answer the questions with self-formulated responses and do quantitative calculations. The allowed support material is constraint to a non-programmable calculator.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Signal description in time and frequency, System theory, Basic knowledge in theory of probability, Basic knowledge in digital communications engineering

The following modules should be passed before the participation:
- Höhere Mathematik 1-3
- Signale
- Nachrichtentechnik 1 (Part of Systeme)
- Nachrichtentechnik 2

Content:
Introduction to mobile communication systems; models for mobile radio channels: path loss models, slow fading (shadowing), fast fading channel, frequency and time selective channels, delay and Doppler spread, multipath propagation. Derivation of error probabilities due to fading and noise, equalization for mobile communication systems: maximum ratio combining, zero-forcing, MMSE equalizer, Viterbi algorithm; channel and noise estimation. The physical layer of the existing UMTS and its successor LTE, associated with an introduction of CDM(A), OFDM(A), MIMO and scheduling techniques.

The modul is offered only in English.

Intended Learning Outcomes:
After successful completion of the module the student knows about wave propagation in mobile communications and resultant effects. He further knows how to adapt transmitter and receiver to combat these effects. He finally gets an insight into the physical layer of the three mobile communications standards used in Europe: GSM, UMTS, and its successor LTE.

Teaching and Learning Methods:
Lerning method:
In addition to the students' personal study, additional knowledge is acquired by lab exercises which are supported by tutor hours.

Teaching method:
During the lectures students are instructed in a teacher-centered style with demonstrations at the PC. The lecture is supported by lab exercises to gain hands-on experience with selected problems.

Media:
The following media will be used:
- Presentations
- Demonstrations at the PC
- Script
- Downloadable exercises with solutions
- Matlab-programs to illustrate the content

Reading List:
The following literature is recommended:
- Molisch, A. F.: Wireless Communications. Wileys, 2005
- Sklar, B.: Digital Communications. Prentice Hall, 2nd edition, 2001
- Tse, D.; Viswanath, P.: Fundamentals of Wireless Communications. Cambridge 2006

Responsible for Module:
Kramer, Gerhard

Courses (Type of course, Weekly hours per semester), Instructor:
VU Mobile Communications 4SWS
Gerhard Kramer

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

EI76211: Topics in Machine Intelligence Research [RTLDV]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The exam of the lecture ¿Topics in Machine Intelligence Research¿ is taken in the form of four homework assignments to be submitted in writing. The content of these homework assignments should be to work out research questions that can serve as the basis for a potential master's thesis, based on a selection of the content that has been presented in the previous lectures since the last homework assignment. In addition a motivational statement - based on current scientific literature - in the style of an abstract must be given. Furthermore, the students must then evaluate each other's homework assignments as part of an anonymous peer review process before the final grading takes place. Participation in the peer review is mandatory. For the final evaluation, the three top-rated homework assignments of each student are used at the end of the semester. Each of these three homework assignments will be weighted equally.

Repeat Examination:

(Recommended) Prerequisites:
Basic lectures of the chair should be attended or already completed (computer vision, information retrieval, time-varying systems)

Content:
Current research topics of the chair are prepared for students, presented and discussed. The topics can change from semester to semester. The different topics can emphasize both practical and theoretical aspects. In addition to the lectures by the chair staff, guest lecturers from business and science are invited to present case studies, current research projects or design challenges to the students.

Intended Learning Outcomes:
After successfully completing the module, the students understand the current research topics in data processing. They also understand the connection of this research work with projects and tasks outside of TUM. They will learn the ability to analyze the state-of-the-art on the research topics addressed and to independently identify relevant tasks.

Teaching and Learning Methods:
The lectures should have a duration of approx. 60 minutes and then leave enough time for a moderated discussion, in which the students can exchange ideas with the respective speaker and ask questions related to the lecture. To deepen the content, the event's Moodle course will also include literature on the respective topics in addition to the slides of the speakers, which should provide an entry point for the students' own research. As part of a weekly question and answer session, students also have the opportunity to collect feedback on their ideas and get answers to methodological questions.

Media:
Presentation with slides and blackboard; interactive discussion

Reading List:
Lecture documents accessible via Moodle, relevant articles on the subject areas, which are provided electronically in advance

Responsible for Module:
Diepold, Klaus; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Topics in Machine Intelligence Research (lecture, 2 SWS)
Diepold K (Gronauer S, Volk T)

Topics in Machine Intelligence Research - external lecturers (exercise, 2 SWS)
Gronauer S (Volk T), Röhrl S

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

IN2028: Business Analytics

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination takes the form of a written 90 minutes test, in which students solve problems to prove they understand the functioning of various methods and their assumptions. Participants demonstrate their ability to interpret the results of different statistical processes and to evaluate their model quality in the exercises. The correct responses require the independent construction of analytical solutions with the help of techniques learned in the module.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
IN0007 Fundamentals of Algorithms and Data Structures, IN0008 Fundamentals of Databases

Content:
Inferential Statistics, Multi-linear Regression, Logistic and Poisson Regression, Naïve Bayes and Bayes Nets, Decision Tree Classifiers, Data Preparation, Evaluation of Classifiers and Learning Theory, Ensemble Methods and Clustering, Dimensionality Reduction, Association Rules

Intended Learning Outcomes:
After successful completion of the module students are familiarized with common methods of classification, numerical prediction and Clustering. They know the assumptions of these processes and understand their functioning, as well as their typical operational applications. Participants are able to analyze data sets with the programming language R and can interpret the results of these analyses.

Teaching and Learning Methods:
The module consists of a lecture and a content-aligned tutorial. The lecturer presents the content of the module, parts of the corresponding literature and application examples from practice interactively. Students are accustomed with the statistical methods and learn to differentiate their usage. In the tutorial participants solve exercises in supervised single person work and evaluate the respective Data Mining techniques. In addition, they practice to solve common problems by approaching empirical case studies in teamwork together with their tutor. Students learn to develop their own, data-based solution concepts, and to constructively criticize their own work. Participants particularly train their technical data mining abilities at the PC with the data processing software R.

Media:
Script, exercise sheets, PowerPoint, PC and E-Learning platform

Reading List:
- Ian Witten, Eibe Frank: Data Mining: Practical Machine Learning Tools and Techniques, 3rd ed., Morgan Kauffman, 2011 (E-Book http://proquest.tech.safaribooksonline.de.eaccess.ub.tum.de/9780123748560)
- Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirnai: An Introduction to Statistical Learning, Springer, 2014 (E-Book http://www-bcf.usc.edu/%7Egareth/ISL/)
- Jay Kearns: Introduction to Probability and Statistics using R, 2010 (E-Book http://cran.r-project.org/web/packages/IPSUR/vignettes/IPSUR.pdf)

Responsible for Module:
Bichler, Martin; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Business Analytics, Exercise Session (IN2028) (exercise, 2 SWS)
Bichler M [L], Heidekrüger S, Sutterer P

Business Analytics (IN2028) (lecture, 2 SWS)
Bichler M

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

IN2062: Techniques in Artificial Intelligence

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor/Master	German/English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The duration of the written exam is 90 minutes. In the written exam students should prove to be able to identify a given problem and find solutions within limited time.
A collection of formulas and tables required to solve the given problems is provided. Students are only allowed to bring pens and a calculator (non-progammable). The questions require to solve problems mathematically and to answer questions in natural language.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
IN0007 Fundamentals of Algorithms and Data Structures, IN0015 Discrete Struktures

Content:
The course gives an overview of application areas and techniques in Artificial Intelligence. The course introduces the principles and techniques of Artificial Intelligence based on the textbook of Russell and Norvig (see below). The course covers the following topics:
- design principles and specification mechanisms for rational agents;
- problem solving using heuristic search: heuristic search techniques, optimizing search;
- problem solving using knowledge-based techniques: logic and inference techniques; reasoning about space and time; representation of ontologies; representation and reasoniong in the common sense world;
- problem solving using uncertain knowledge and information: basic concepts of probability and decision theory; Bayesian Networks; planning with Markov decision problems;
- action planning: automatic generation of partially ordered action plans; planning and execution;
- machine learning: learning decision trees; inductive learning; probably approximately correct learning; reinforcement learning.

Intended Learning Outcomes:
The participants will attain capabilities to solve complex problems using fundamental methods and techniques of artificial intelligence. The techniques include agent-based problem solving, problem solving through (heuristic) search, the representation of knowledge, reasoning mechanisms, problem solving under uncertainty, action planning and machine learning.
Examples are search algorithms, methods of logical inference, as well as computation of state probabilities of Bayesian networks and hidden Markov models.

Teaching and Learning Methods:
The module consists of a lecture and exercise classes. The content of the lecture is presented via slides, which are

completed during the lecture using the blackboard. Also, the learning progress is checked during the lecture using the survey tool Tweedback. Students are encouraged to additionally study the relevant literature. In the exercise classes, the learned content is applied to practical examples to consolidate the content of the lecture.

Media:
Slides, assignment sheets

Reading List:
Stuart Russel and Peter Norvig: Artificial Intelligence - A Modern Approach, Prentice Hall

Responsible for Module:
Althoff, Matthias; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Techniques in Artificial Intelligence (IN2062) (lecture with integrated exercises, 4 SWS)
Althoff M, Klischat M, Kochdumper N, Koschi M, Maierhofer S, Rettinger A, Wang X

For further information in this module, please click
campus.tum.de or here.

Module Description

IN2309: Advanced Topics of Software Engineering

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	German/English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
8	240	150	90

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In the written exam (100 minutes) students should prove to be able to identify a given problem and find solutions within limited time. The examination will completely cover the content of the lectures. The anwers will require own formulations. In addition, some modeling may be required.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Introduction to Software Engineering (IN0006)

Content:
Developing large software systems necessitates tightly intertwining and synchronizing both the activities in the development process and the generated artifacts. Central success criteria include
- Iterative elicitation and implementation of the requirements;
- Architecture as the backbone of development; and
- Mastering quality in its different facets.
This class on Advanced Software Engineering demonstrates how requirements engineering, specification, architecture, detailed design, coding, software quality, and quality assurance interweave. Specifically, we discuss how non-functional requirements are reflected in the architecture; which tradeoffs exist with functional requirements as well as external and internal quality attributes; and how these requirements can be formulated and verified by tests.
We will consider:
1. Requirements Engineering: Techniques for elicitation, analysis, prioritization, specification, validation of functional and non-functional requirements; anti-requirements.
2. Software Architecture: Principles, views&styles, architecture documentation, patterns, frameworks, reference architectures, product lines, analysis of an architecture s quality and of trade-offs.
3. Software Quality: Internal and external quality attributes, among others: maintainability, testability, understandability and performance, security, availability; software metrics
4. Quality Assurance: Assessment, prioritization, conflict resolution and reviews of requirements; assessments of architectures w.r.t. internal and external quality attributes; tests and reviews for functional and non-functional requirements in the code; fault models.
5. Influence of the development process.

Intended Learning Outcomes:
At the end of the class, students understand the central goals and methods of requirements engineering. They know all relevant software quality attributes. They know how to elicit, specify and manage respective requirements;

how they are reflected in architectures and, conversely, how architecture influences these attributes; how requirements, architectures and code can be assessed w.r.t. these attributes; and what the influence of the development process is. They can apply this knowledge in smaller projects in practice.

Teaching and Learning Methods:
This module comprises lectures and accompanying tutorials. The contents of the lectures will be taught by talks and presentations. Students will be encouraged to study literature and to get involved with the topics in depth. In the tutorials, concrete problems will be solved - partially in teamwork - and selected examples will be discussed.

Media:
Lecture with slides

Reading List:
McConnell, Code Complete: A Practical Handbook of Software Construction, 2nd edition, Microsoft, 2004
Summerville, Software Engineering 9, Prentice Hall, 2010
Brooks, The Mythical Man Month, Addison-Wesley Longman, 1995
Rombach, Endres: A Handbook of Software and Systems Engineering, Addispn Wesley, 2003
Bass et al., Software Architecture in Practice, Addison Wesley, 3rd edition, Addison Wesley, 2012
Clements et al., Documenting Software Architectures, 2nd edition, Addison Wesley, 2010
Clements et al., Evaluating Software Architectures, Addison Wesley, 2001
Reussner, Hasselbring, Handbuch der Software-Architektur (in German), 2006
Jackson, Problem Frames, ACM Press, 2000
Sommerville, Sawyer: Requirements Engineering: A Good Practice Guide, John Wiley, 1997
Lamsweerde, Requirements Engineering: From System Goals to UML Models to Software Specifications, John Wiley, 2009
Goucher, Riley, Beautiful Testing, OReilly, 2009
Wagner, Software Product Quality Control, Springer, 2013

More references will be provided in class.

Responsible for Module:
Pretschner, Alexander; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Topics of Software Engineering (IN2309, IN2126) (exercise, 2 SWS)
Pretschner A [L], Ahmadvand M (Petrovska A, Schnappinger M, Stöckle P), Ibrahim A, Salem A, Schmidt T

Advanced Topics of SW Engineering (IN2309, IN2126) (lecture, 4 SWS)
Pretschner A [L], Pretschner A (Elsner D)

For further information in this module, please click
campus.tum.de or here.

Specialization in Technology: Industrial Engineering (minor)

Technische Universität München

Module Description

IN2028: Business Analytics

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination takes the form of a written 90 minutes test, in which students solve problems to prove they understand the functioning of various methods and their assumptions. Participants demonstrate their ability to interpret the results of different statistical processes and to evaluate their model quality in the exercises. The correct responses require the independent construction of analytical solutions with the help of techniques learned in the module.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
IN0007 Fundamentals of Algorithms and Data Structures, IN0008 Fundamentals of Databases

Content:
Inferential Statistics, Multi-linear Regression, Logistic and Poisson Regression, Naïve Bayes and Bayes Nets, Decision Tree Classifiers, Data Preparation, Evaluation of Classifiers and Learning Theory, Ensemble Methods and Clustering, Dimensionality Reduction, Association Rules

Intended Learning Outcomes:
After successful completion of the module students are familiarized with common methods of classification, numerical prediction and Clustering. They know the assumptions of these processes and understand their functioning, as well as their typical operational applications. Participants are able to analyze data sets with the programming language R and can interpret the results of these analyses.

Teaching and Learning Methods:
The module consists of a lecture and a content-aligned tutorial. The lecturer presents the content of the module, parts of the corresponding literature and application examples from practice interactively. Students are accustomed with the statistical methods and learn to differentiate their usage. In the tutorial participants solve exercises in supervised single person work and evaluate the respective Data Mining techniques. In addition, they practice to solve common problems by approaching empirical case studies in teamwork together with their tutor. Students learn to develop their own, data-based solution concepts, and to constructively criticize their own work. Participants particularly train their technical data mining abilities at the PC with the data processing software R.

Media:
Script, exercise sheets, PowerPoint, PC and E-Learning platform

Reading List:
- Ian Witten, Eibe Frank: Data Mining: Practical Machine Learning Tools and Techniques, 3rd ed., Morgan Kauffman, 2011 (E-Book http://proquest.tech.safaribooksonline.de.eaccess.ub.tum.de/9780123748560)
- Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirnai: An Introduction to Statistical Learning, Springer, 2014 (E-Book http://www-bcf.usc.edu/%7Egareth/ISL/)
- Jay Kearns: Introduction to Probability and Statistics using R, 2010 (E-Book http://cran.r-project.org/web/packages/IPSUR/vignettes/IPSUR.pdf)

Responsible for Module:
Bichler, Martin; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Business Analytics, Exercise Session (IN2028) (exercise, 2 SWS)
Bichler M [L], Heidekrüger S, Sutterer P

Business Analytics (IN2028) (lecture, 2 SWS)
Bichler M

For further information in this module, please click
campus.tum.de or here.

Module Description

IN2211: Auction Theory and Market Design

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination takes the form of a written 90 minutes test, in which students solve problems to prove they are able to use, analyze and assess the game theoretical models of auctions. The additional answering of theory questions ensures participants understand the fundamental challenges of combinatorial auctions. Moreover, the correct responses require independent defense of the choice of auction format based on desired properties of the market allocation such as efficiency or revenue maximization for example. All problems and questions demand the students to phrase their individual responses.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
IN0022 Informations Systems II, operations research/linear programming

Content:
Basic game theoretical concepts (dominant strategies, Nash equilibrium under complete and incomplete information), Mechanism Design Theory, basics of auction theory (sealed bid and open auction formats, Revenue Equivalence, Optimal Auctions), Combinatorial Auctions, Assignment Markets, challenges of combinatorial auction design (iterative combinatorial auctions and combinatorial clock auctions), applications of combinatorial auctions (spectrum and procurement auctions), approximation mechanisms, Matching Markets

Intended Learning Outcomes:
After successful completion of the module students understand the economic properties of various auction formats. They know different game theoretical approaches to model the strategic interactions between the auctioneer and bidders. Furthermore, they understand the fundamental strategical challenges of various auction mechanisms and computational questions related to the determination of allocations and payments. Moreover, they can independently defend the choice of auction format based on desired properties of the market allocation such as efficiency or revenue maximization for example.

Teaching and Learning Methods:
The module consists of a lecture and a content-aligned tutorial. The lecturer presents the content of the module, parts of the corresponding literature and application examples for various auctions interactively. Students are accustomed with different auction formats and their modeling, and learn to differentiate their applications. In the tutorial participants solve exercises in single person and team work, and evaluate the respective game- and auction theoretical models. Thus, students learn particularly to assess the basic challenges of combinatorial auction design and to constructively criticize their own work.

Media:
Script, exercise sheets, PowerPoint, PC and E-Learning platform

Reading List:
Y. Shoham and K. Leyton-Brown: Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations. Chapters 3, 5, 6, 10, 11, 12. For class 2 and 3.: N. Nisan, T. Roughgarden, E. Tardos and V. Vazirani (editors): Algorithmic Game Theory. Chapters 9 and 11 by Nisan. For class 2, 4 and 6: V. Krishna: Auction Theory. Chapters 16 and 17 on multi-object auctions.

Responsible for Module:
Bichler, Martin; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Auction Theory and Market Design (IN2211) (lecture, 2 SWS)
Bichler M

Exercises for auction theory and market design (IN2211) (exercise, 2 SWS)
Bichler M [L], Fichtl M, Schwarz G, Waldherr S

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

MA4800: Foundations of Data Analysis

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
8	240	150	90

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The exam will be in written form (90 minutes). Students demonstrate that they have gained deeper knowledge of definitions and main mathematical tools and results in linear algebra, convex optimization, differential geometry presented in the course and their applicability in data analysis. The students are expected to be able to derive the methods, to explain their properties, and to apply them to specific examples.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
MA1001 Analysis 1, MA1002 Analysis 2, MA1101 Linear Algebra and Discrete Structures 1, MA1102 Linear Algebra and Discrete Structures 2,MA0901 Lineare Algebra for Informatics, MA0902 Analysis for Informatics, IN0018 Discrete Probability Theory, MA1401 Introduction to Probability Theory. Vorteilhaft: MA2501 Algorithmic Discrete Mathematics, MA2503 Introduction to Nonlinear Optimization

Content:
I) Representations of data as matrices
a. Many data vectors form a matrix
b. Review of basic linear algebra
c. Linear dependence and concept of rank
d. Approximate linear dependence with varying degree of approximation: Singular value decomposition /Principal Component Analysis
e. Redundancy of data representations -> orthonormal bases, frames and dictionaries
f. Fourier basis as singular vectors of spatial shift
g. Fast Fourier Transform
II) Linear dimension reduction
a. Johnson-Lindenstrauss (JL) Lemma
b. Review of basic probability, random matrices
c. Random Matrices satisfying JL with high probability
d. Fast JL embeddings
e. Sparsity, low rank as structured signal models
f. Compressed sensing
g. Matrix completion and low rank matrix recovery
h. Optimization review
j. Dictionary Learning
III) Non-linear dimension reduction
a. Manifolds as data models
b. Review of differential geometry

c. ISOMAP
d. Diffusion maps
e. Importance of Nearest neighbor search, use of JL
IV) Outlook: Data Analysis and Machine Learning

Intended Learning Outcomes:
After successful completion of the module students are able to understand and apply the basic notions, concepts, and methods of computational linear algebra, convex optimization, differential geometry for data analysis. They master in particular the use of the singular value decomposition and random matrices for low dimensional data representations. They know fundamentals of sparse recovery problems, including compressed sensing, low rank matrix recovery, and dictionary learning algorithms. They understand the representation of data as clusters around manifolds in high dimension and they know how to use methods for constructing local charts for the data.

Teaching and Learning Methods:
The module is offered as lectures with accompanying practice sessions. In the lectures, the contents will be presented in a talk with demonstrative examples, as well as through discussion with the students. The lectures should animate the students to carry out their own analysis of the themes presented and to independently study the relevant literature. Corresponding to each lecture, practice sessions will be offered, in which exercise sheets and solutions will be available. In this way, students can deepen their understanding of the methods and concepts taught in the lectures and independently check their progress. At the beginning of the module, the practice sessions will be offered under guidance, but during the term the sessions will become more independent, and intensify learning individually as well as in small groups.

Media:
The following media are used
- Blackboard
- Slides

Reading List:
Golub, Gene H.; Van Loan, Charles F. Matrix computations. Fourth edition. Johns Hopkins Studies in the Mathematical Sciences. Johns Hopkins University Press, Baltimore, MD, 2013
Foucart, Simon; Rauhut, Holger A mathematical introduction to compressive sensing. Applied and Numerical Harmonic Analysis. Birkhäuser/Springer, New York, 2013
P. Gritzmann. Grundlagen der mathematischen Optimierung, Springer, 2013.
D. P. Bertsekas, A. Nedic, A. E. Ozdaglar. Convex Analysis and Optimization, Athena Scientific, 2003.
J.-B. Hiriart-Urruty, C. Lemarechal. Fundamentals of Convex Analysis, Springer, 2001.
Dasgupta, Sanjoy; Gupta, Anupam, "An elementary proof of a theorem of Johnson and Lindenstrauss" (PDF), Random Structures & Algorithms 22 (1): 60¿65, 2003
Krahmer, Felix; Ward, Rachel New and improved Johnson-Lindenstrauss embeddings via the restricted isometry property. SIAM J. Math. Anal. 43 (2011), no. 3, 1269¿1281.
J. B. Tenenbaum, V. de Silva, J. C. Langford, A Global Geometric Framework for Nonlinear Dimensionality Reduction, Science 290, (2000), 2319¿2323.
Saxena, A. Gupta and A. Mukerjee. Non-linear dimensionality reduction by locally linear Isomaps, . Lecture Notes in Computer Science, 3316:1038¿1043, 2004.
Chen, Guangliang; Little, Anna V.; Maggioni, Mauro Multi-resolution geometric analysis for data in high dimensions. Excursions in harmonic analysis. Volume 1, 259¿285, Appl. Numer. Harmon. Anal., Birkhäuser/Springer, New York, 2013.

Responsible for Module:
Fornasier, Massimo; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

Technische Universität München

For further information in this module, please click
campus.tum.de or here.

Module Description

MW0124: Systems Engineering [SE]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor/Master	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In einer schriftlichen Prüfung (90 min) sind die vermittelten Inhalte auf verschiedene Problemstellungen aus der Vorlesung und Übung anzuwenden. Die schriftliche Prüfung unterteilt sich in zwei Teilbereiche. Im ersten Teil der Prüfung werden theoretischen Grundlagen aus der Vorlesung geprüft (Fragenteil). Im zweiten Teil werden praktische Problemstellungen hauptsächlich aus der Übung rechnerisch gelöst (Rechenteil).
Als Hilfsmittel sind ein nicht-programmierbarer Taschenrechner und ein Wörterbuch für ausländische Studierende zugelassen.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
keine

Content:
Ingenieure in Industrie und Wissenschaft müssen fähig sein, Projekte erfolgreich zu planen und durchzuführen. Für das Management von komplexen, interdisziplinären Aufgaben wurden in den vergangenen Jahrzehnten verschiedene systemtechnische Methoden entwickelt. Diese Methoden und Prozesse können in allen Bereichen der Industrie und Wissenschaft angewendet werden.

Die Vorlesung beinhaltet: Systemdefinition, mathematische und konzeptionelle Grundlagen, Modellierung und Simulation von Systemen, Systemoptimierung durch lineare und dynamische Programmierung, Bewertungsmethoden, Grundlagen der Entscheidungstheorie und systemtechnisches Management. Weiterhin werden Methoden für die Planung, Überwachung und Durchführung von Projekten im Hinblick auf Technologie, Zeit und Kosten behandelt. Die verschiedenen Methoden werden in Übungen mit Beispielen aus dem Luftfahrtbereich, allgemeiner Maschinenbau, Transportsysteme und Sicherheitstechnik, dargestellt und verifiziert.

Intended Learning Outcomes:
Nach der Teilnahme an der Modulveranstaltung Systems Engineering sind die Studierenden in der Lage, komplexe technische Systeme zu verstehen und zu bewerten. Des Weiteren sind die studierenden in der Lage technische Problemstellungen eigenständig zu analysieren, bewerten und eigene Lösungevorschläge zu erarbeiten um unterschiedliche Problemstellungen aus der Praxis zu lösen. Außerdem können die Studierenden nach Abschnuss dieses Moduls eigenständig Projekte bewerten, deren Erfolgsfaktoren identifizieren und Maßnahmen für den erfolgreichen Abschluss ergreifen.

Teaching and Learning Methods:
In der Vorlesung werden die Lehrinhalte anhand von Vortrag, Präsentation und Tafelanschrieb vermittelt.

Media:
Vortrag, Präsentation, Handzettel, Tafelanschrieb

Reading List:
Systems Engineering - Methodik und Praxis W.F. Daenzer, F. Haberfellner, ISBN 3-85743-998-X

Einstieg ins Systems Engineering - Optimale, nachhaltige Lösungen entwickeln und umsetzen, Rainer Züst, ISBN 3-85743-721-9

Operations Research: An Introduction H.A. Taha, ISBN 0-13-048808-9

Objektorientierte Softwaretechnik - mit UML, Entwurfsmustern, Java Bernd Brügge, Allen H. Dutoit, ISBN 3-8273-7082-5

Responsible for Module:
Brandstätter, Markus; Dipl.-Inf. (Univ.)

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click
campus.tum.de or here.

Electives in Management and/or Technology

Within the framework of the management-technical elective, students earn a total of 24 credits in a management or technical subject area. The following is an example of such a catalog.

Electives from Innovation and Entrepreneurship

Technische Universität München

Module Description

WIB18812_1: Advanced Seminar Innovation & Entrepreneurship: Ideation & Venture Creation

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Master	English	one semester	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The grading is based on a research paper (10-15 pages, 75% of grade) and a presentation (15 min + 15 min interaction with the audience, 25% of grade). The research paper and the presentation will be conducted in groups formed in the introductory session. An assessment sheet filled in by the students and handed in with the research paper clarifies students' individual contribution to the research paper. As every student will present in the final presentation, every students' contribution is clearly identifiable and appraisable, thus, students can be graded individually. Based on the research paper it is examined to which extent students are able to elaborate complex topics in the field of entrepreneurship research. The research paper is a means to measure how students were able to understand previous academic literature in the field of entrepreneurship, how they achieved to define their own research question, collect and analyze data, and provide a relevant, novel, and interesting contribution to entrepreneurship research. A final presentation measures students' communicative competencies and proves if students are able to present their findings in a comprehensible, precise and demonstrative way as well as whether they are able to perform powerfully and professionally.

Repeat Examination:
Next semester / End of Semester

(Recommended) Prerequisites:
none

Content:
The module deals with different topics within entrepreneurship research such as
- discovering entrepreneurial role models,
- psychology of entrepreneurship,
- entrepreneurial leadership,
- ideation and venture creation,
- venture growth and
- internationalization and strategic entrepreneurship.

The module prepares students for the scientific work in their master theses and provides them with deepening insights into scientific literature on entrepreneurship. Besides writing a seminar paper, this involves presenting their final results.

Intended Learning Outcomes:
Upon successful completion of this module, students will be able (1) to read and (2) understand scientific literature on the topic of entrepreneurship. Furthermore, students are able (3) to create their own research paper, i. e., identifying a relevant, interesting, and new research topic in the field of entrepreneurship, crafting a strong title, writing a compelling and strong introduction (and abstract), execute an extensive literature review and applying theory, structure the research paper meaningful, writing a strong discussion and conclusion, and complying with the ethics of writing. Additionally, they will be able (4) to present their research paper and (5) summarize their findings. Moreover, students learn how (6) to lead a scientific discussion. Finally, they (7) understand the process of scientific publication. Moreover, working in groups will provide students with communication and cooperation skills.

Teaching and Learning Methods:
The module consists of an introduction to scientific writing where the topics for each student's research paper will be decided. Topics vary and cover entrepreneurship on an individual (e.g., entrepreneurial decision making, entrepreneurial intentions), team (e.g., entrepreneurial team formation, entrepreneurial exits), or organizational level (e.g., interplay of form, structure, and embeddedness in corporate entrepreneurship). Based on their topic students prepare their research paper which they will present at the end of the module. Upon prior discussion on different research methods and how to use them, the students will identify and apply a research methodology that best addresses their identified research question, i.e., they can apply empirical research methods (qualitative or quantitative), a literature review, or conduct a conceptual paper. Furthermore, the module involves (group and/or) individual feedback sessions, where students can share their progress and receive feedback. The students are supervised by the instructors of the module who are members the chair. Within the module the topics will be discussed after the final presentations.

Media:
MS Office, PowerPoint, Whiteboard, Flipchart

Reading List:
Hisrich, R. D./Peters, M. P./Shepherd, D. A.: Entrepreneurship, 8th edition, McGraw-Hill, 2010
Further readings will be announced at the course introduction.

Responsible for Module:
Patzelt, Holger; Prof. Dr. rer. pol.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Seminar Innovation & Entrepreneurship (WIB18812_1): Ideation & Venture Creation _ Group 2 (seminar, 4 SWS)
Patzelt H [L], Patzelt H, Rosenberger J

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

WI000116: Lead User Project [LUP]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	German	one semester	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The progress of the project is verified several times during the different project phases.
- Midterm presentation (voluntary): Students have to show that they developed critical knowledge and competencies with the industry of the project partner and that they identified trends and needs in the respective industry.
- Final presentation (30 minutes): Students propose different workshop combinations of lead users and assess constellations of expert panels based on their industry insights they developed over the course of the project.
- Project report (25 pages): Students document their key learnings along the entire project process as well as how the project contributes to their personal development into a successful career in management.
Students learn to present results in front of our cooperation partner. Furthermore, they document the results in a project report including the scientific theory of the lead user method.
Consistently, grading of the module is based on a project work (project report 25 pages and presentation 30 minutes). The progress of the project is verified several times during the different project phases.
Students have the possibility of a midterm presentation in which they have to show that they dealt with the industry of the project partner. They show their ability to identify and consider trends and needs in the respective industry. This midterm presentation is highly recommended because students can gain further knowledge for their final presentation. With this presentation the final grade can be improved by 0,3/0,4.
With the final presentation students show on the one hand the project progress and propose different workshop combinations of lead users. On the other hand they show their ability to conduct interviews with experts and to communicate and present on a high business level. They are able to judge the branch-specific challenges and identify experts who complete each other perfectly in workshops.
In the project report the students show their ability to document their project process and their findings in a clear and comprehensible manner. Furthermore they show their ability to analyze and evaluate the challenges in this industry.
With this project work students show that they can present results in front of our cooperation partner. Furthermore they show that they can compose a project report in which they formulate their practical results and combine them with the scientific theory of the lead user method.
The project work is conducted by teams of 4 students. Students demonstrate their ability within a team to manage resources, and deadlines through timely submission of the enumerated tasks. The project work is set up in a way which enables the identification and evaluation of each student's individual contribution to the project's success.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Fundamentals of Technology and Innovation Management

Content:
The lead user project is a practical module. Participants in teams of 4 perform a lead user project in cooperation with an industry partner.
- We apply the lead user method developed by Eric von Hippel at MIT
- Starting point is the industry of our cooperation partner

The participants learn to understand the target industry:
- Search for trends and needs in the industry
- Identification of lead users

Students get to know the cooperation partner as well as its industry. The students are working independently and are coached regularly. In addition two professional presentation coachings are offered. Dr. Christian Hackl from TUMtech gives Feedback how to improve presentation content and style.

A successful participation encourages students to be creative, proactive, and work in teams.

Intended Learning Outcomes:
After successful completion of this module students will be able to describe the lead user method and understand its advantages. Students will know different methods to identify trends and needs. They will be able to deal intensively with a targeted industry and can evaluate the challenges in this industry. They will be able to identify experts and to develop a workshop for these experts. The students will be able to present their results in front of company representatives. Furthermore, they will be able to document their results in a clear and comprehensible manner.
Students can contribute an own part to a team's work output. Students are able to exchange in a professional and academic manner within a team. They show that they are able to integrate involved persons into the various tasks considering the group situation. Furthermore the students conduct solution processes through their constructive and conceptual acting in a team.

Teaching and Learning Methods:
During a real life innovation project students learn the theory of the lead user method and apply it during the module. The module is a practical project and the students get to know the different stages of a lead user project and work together with our industry partner. The students deal intensively with the target industry.
- During the kick-off the lead user method is explained
- The students work independently and are coached regularly during the project
- Students present their results after the first phase (need identification) and at the end of the project (lead user identified)
- Before the presentations a professional presentation coaching with Dr. Christian Hackl (TUMtech) will take place

Media:
Participants receive all presented slides and research papers about the lead user method.

Reading List:
- Glen L. Urban / Eric von Hippel (1988). Lead User Analyses for the Development of New Industrial Products, Management Science, Vol. 34, No. 5, pp. 569-582.
- Herstatt, C., Lüthje, C., & Lettl, C. (2003). Fortschrittliche Kunden zu Breakthrough-Innovationen stimulieren. In Management der frühen Innovationsphasen (pp. 57-71). Gabler Verlag.
- Henkel, J., Jung, S. (2009) The Technology-Push Lead User Concept: A New Tool for Application Identification, http://www.researchgate.net/publication/228820209_The_Technology-Push_Lead_User_Concept_A_New_Tool_for_Application_Identification/links/00b7d521ce2d489500000000
- Lüthje, C. (2000), Kundenorientierung im Innovationsprozess, S. 130-152.
- v. Hippel, E. / Thomke, S. / Sonnack, M. (1999), Creating Breakthroughs at 3M, Harvard Business Review, September-October, S. 47-57.
- v. Hippel, Eric. Democratizing innovation. MIT press, 2005.

Responsible for Module:
Henkel, Joachim; Prof. Dr. rer. pol.

Courses (Type of course, Weekly hours per semester), Instructor:
Lead-User Project (WI000116) (seminar, 4 SWS)
Henkel J, Obermeier D

For further information in this module, please click
campus.tum.de or here.

Module Description

WI001166: Advanced Topics in Innovation & Entrepreneurship: Entrepreneurial Prototyping

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The grading is based on a research paper (10-15 pages, 75% of grade) and a presentation (15 min + 15 min interaction with the audience, 25% of grade). The research paper and the presentation will be conducted in groups formed in the introductory session. An assessment sheet filled in by the students and handed in with the research paper clarifies students' individual contribution to the research paper. As every student will present in the final presentation, every students' contribution is clearly identifiable and appraisable, thus, students can be graded individually. Based on the research paper it is examined to which extent students are able to elaborate complex topics in the field of entrepreneurship research. The research paper is a means to measure how students were able to understand previous academic literature in the field of entrepreneurship, how they achieved to define their own research question, collect and analyze data, and provide a relevant, novel, and interesting contribution to entrepreneurship research. A final presentation measures students' communicative competencies proves if students are able to present their findings in a comprehensible, precise and demonstrative way as well as whether they are able to perform powerfully and professionally.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
none

Content:
The module deals with different topics within entrepreneurship research such as

- discovering entrepreneurial role models, this might include to explore
o links between role models and entrepreneurial intentions
o reasons for the choice of the entrepreneurial career
- psychology of entrepreneurship, this might include to explore
o personality dimensions of entrepreneurs
o entrepreneurial cognition
- entrepreneurial leadership, this might include to explore
o behavioral forms of leadership
o creating and managing innovative organizations
- ideation and venture creation, this might include to explore
o the process of obtaining creative ideas
o the process model of entrepreneurial venture creation
- venture growth, this might include to explore
o how new ventures grow and where growth occurs
o different impact factors on new venture growth

- internationalization and strategic entrepreneurship, this might include to explore
o the speed of entrepreneurial internationalization
o enabling forces of technology, competition, perceptions, knowledge and networks
The module provides students with deepening insights into entrepreneurship literature. Besides writing a seminar paper, this involves presenting their final results.

Intended Learning Outcomes:
Upon successful completion of this module, students will be able to read and understand related literature on the topic of entrepreneurship. Furthermore, students are able to create their own research paper. Additionally, they will be able to present their paper and summarize their findings. Moreover, students learn how to lead a discussion on their topic. Finally, they understand entrepreneurial processes.
At the end of the module, students will be able to:
- explain entrepreneurship concepts related to a specific topic.
- discuss current topics within the field of entrepreneurship.
- apply previously discussed approaches to topic specific issues within the field of entrepreneurship.
- evaluate these approaches and their outcomes.
- develop suitable approaches for specific entrepreneurship issues.

Teaching and Learning Methods:
The module consists of an introduction to scientific writing where the topics for each student's research paper will be decided. Topics vary and cover entrepreneurship on an individual (e.g., entrepreneurial decision making, entrepreneurial intentions), team (e.g., entrepreneurial team formation, entrepreneurial exits), or organizational level (e.g., interplay of form, structure, and embeddedness in corporate entrepreneurship). Based on their topic students prepare their research paper which they will present at the end of the module. Upon prior discussion on different research methods and how to use them, the students will identify and apply a research methodology that best addresses their identified research question, i.e., they can apply empirical research methods (qualitative or quantitative), a literature review, or conduct a conceptual paper. Furthermore, the module involves (group and/or) individual feedback sessions, where students can share their progress and receive feedback. The students are supervised by the instructors of the module who are members the chair. Within the module the topics will be discussed after the final presentations.

Media:
MS Office, PowerPoint, Whiteboard, Flipchart

Reading List:
Hisrich, R. D. / Peters, M. P. / Shepherd, D. A.: Entrepreneurship, 8th edition, McGraw-Hill, 2010 (optional)
Obligatory readings will be announced at the course introduction.

Responsible for Module:
Breugst, Nicola; Prof. Dr. rer. pol.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Topics in Innovation & Entrepreneurship (WI001166): Entrepreneurial Prototyping (seminar, 4 SWS)
Breugst N [L], Leibinger H, Reetz D

For further information in this module, please click
campus.tum.de or here.

Electives from Marketing, Strategy and Leadership

Module Description

WIB17003: Advanced Seminar Marketing, Strategy & Leadership: Judgement and Strategic Decision Making

Judgement and Strategic Decision Making

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination comprises a research paper (seminar paper (10 pages excl. literature & attachments) with presentation (30 minutes incl. discussion)), which demonstrates that students
- are able to understand and interpret the scientific literature on a specific topic in the field of strategic decision-making, and are able to draw upon scientific literature in a results-oriented and structured manner.
- are able to apply scientific methods to provide answers to questions in the field of strategy and organization that are relevant to business practice.
- possess presentation and communication skills that enable them to present, in a clear and structured manner, their findings on scientific challenging topics they have worked on independently, and to discuss the applicability of their findings to business practice.
The final grade is an averaged grade from the seminar paper (75%) and the presentation (25%).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
None

Content:
How are decisions actually made in theory and practice?
This module enriches students' knowledge of judgment and strategic decision making (JSDM) on a theoretical and a practical level. JSDM has been regarded as the core of an organization's operation and a core competence of any top-level executive. In this course, we will introduce different perspectives on JSDM. More specifically, we will discuss three different perspectives, First, what are the drivers of individual, group and organizational decisions from a psychological perspective including common biases and errors present in strategic decision? Second, how can decisions nowadays be based on data science approaches including AIs and machine learning algorithms? Third, how are decisions actually made in practice and what are key questions managers face when making strategic decisions?

Intended Learning Outcomes:
Theory:
Students know and understand the most important theories about behavioral decision making from various perspectives in how to make better strategic decisions and be able to apply a framework for how society and management could improve their decision making.

Practice:
Students understand how decision making occurs from a practitioner's point of view and will be able to integrate these viewpoints with scientific theory.

Method:
Students will gain insights into research methods in the applied setting of decision making, data-driven decisions and strategic management research.
They are able to analyze different streams of theory, conduct efficient decision making studies and apply results in practice.
They are able to research, analyze, and evaluate scientific literature.

Teaching and Learning Methods:
Over the course of the semester, students work on a scientific and application-orientated topic. They work both on their own (in particular while working on their seminar paper) and in small groups together with other seminar participants. The lecturers give presentations on the most important theories as well as current research findings on a specific topic in the field of strategy, organization, and leadership (depending on the concrete subject of the seminar). By reading scientific literature (self-study), students deepen their knowledge of theories and methods in the field and get used to working with scientific literature. Guest lectures by regularly changing speakers from the business sector (often high-level decision-makers) as well as case study work enable students to establish a connection between questions from business practice and scientific theories and research findings.

Media:
Slides, case studies, scientific literature

Reading List:
Bazerman, M. H. & Moore, D. (2013). Judgment in Managerial Decision Making (8th ed.). Hoboken, NJ: John Wiley & Sons.
Gigerenzer, G. & Gaissmaier, W. (2011). Heuristic decision making. Annual Review of Psychology, 62, 451-482.
Tversky, A. & Kahnemann, D. (1974). Judgment under uncertainty: Heuristics and biases. Science, 185, 1124-1131.
Weber, E. U. & Johnson, E. J. (2009). Mindful judgment and decision making. Annual Review of Psychology, 60, 53-85.

Responsible for Module:
Welpe, Isabell M.; Prof. Dr. rer. pol.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Seminar Marketing, Strategy & Leadership (WIB17003): Judgment and Strategic Decision Making (seminar, 4 SWS)
Folger N, Höllig C, Rüll H

For further information in this module, please click
campus.tum.de or here.

Module Description

WI001140: Luxury Marketing

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The final grade is based on group presentations. During the module two presentations have to be held. One short presentation (25% of grade, presenting an article - 20 min) aims to prove if students are able to connect the theoretical material on luxury marketing with empirical results of the contemporary research, if they are able to analyze and present an academic article in a clear and organized way, and if their able to provide a personal interpretation of the article. The second presentation (75% of grade, 45 min) assesses if the students understand the main elements of a luxury strategy with a focus on the 4Ps, and if they are able to apply the theoretical learning to a real case by conducting an audit of a luxury brand and by giving recommendations of how to improve the luxury marketing strategy of the assigned brand. They can use the theoretical material (lecturer´s slides) as a support and they have to collect secondary data. This presentation is combined with a written composition that illustrates the results of the audit. The presentations are done by groups of four students. The students will receive an individual grade: the individual contribution will be identified by evaluating a personal recommendation to the luxury brand that each students has to provide as a result of the audit, and by evaluating the individual communication skills. Both presentations are followed by a discussion in which all the students can voluntarily participate.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:

Content:
* First, the module starts with a discussion about how the meaning of luxury evolved from the past until now. It will elaborate how luxury differs from other related concepts.
* Second, it will focus on understanding consumer behavior association with luxury products and brands. In particular, it will identify the underlying drivers of conspicuous consumption (e.g. self-reward, social elevation) and what consumers want to signal through the purchase of luxury products (e.g. status, wealth, power).
* Third, the module will discuss best practices, do's and don'ts, when it comes to building, managing, and extending luxury brands. Especially, the symbolic power and the identity of luxury brands will be discussed.
* Last but not least, it will discuss the 4Ps of luxury marketing and how to leverage them to develop an effective marketing strategy.

Intended Learning Outcomes:
Upon successful completion of this module, students are able (1) to understand the basic elements and the specific challenges of marketing luxury products and (2) to give examples from empirical evidence of the theoretical concepts. They are also able (3) to analyze, (4) review and (5) present academic papers related to the topic of luxury of the contemporary research. Finally, they are able (6) to conduct an audit of a luxury brand (7) by making

recommendations to improve the luxury marketing strategy of the assigned brand and (8) to improve their communication skills.

Teaching and Learning Methods:
The module uses various teaching methods that should help facilitate students' learning. The students are provided during the lectures with theoretical material to acquire the basic knowledge of luxury marketing. The students have to present academic papers in class and discuss them with peers, in order to explore empirical results related to theoretical concepts. They also have to prepare an audit of a luxury brand focused on the 4Ps (product, price, promotion, and place), which they have to present in class, in order to apply in practice the theoretical learning. The audit can be performed using the theoretical material presented in class as a support.

Media:

Reading List:
- Han, Y. J., Nunes, J. C., & Drèze, X. (2010). Signaling status with luxury goods: The role of brand prominence. Journal of Marketing, 74(4), 15-30.
- Wang, Y., & Griskevicius, V. (2014). Conspicuous consumption, relationships, and rivals: Women's luxury products as signals to other women. Journal of Consumer Research, 40(5), 834-854.
- Bellezza, S., Gino, F., & Keinan, A. (2014). The red sneakers effect: Inferring status and competence from signals of nonconformity. Journal of Consumer Research, 41(1), 35-54.
- Mandel, N., Petrova, P. K., & Cialdini, R. B. (2006). Images of success and the preference for luxury brands. Journal of Consumer Psychology, 16(1), 57-69.
- Rucker, D. D., & Galinsky, A. D. (2008). Desire to acquire: Powerlessness and compensatory consumption. Journal of Consumer Research, 35(2), 257-267.
- Griskevicius, V., Tybur, J. M., & Van den Bergh, B. (2010). Going green to be seen: status, reputation, and conspicuous conservation. Journal of personality and social psychology, 98(3), 392.
- Hagtvedt, H., & Patrick, V. M. (2008). Art and the brand: The role of visual art in enhancing brand extendibility. Journal of Consumer Psychology, 18.
- Hagtvedt, H., & Patrick, V. M. (2009). The broad embrace of luxury: Hedonic potential as a driver of brand extendibility. Journal of Consumer Psychology, 19.
- Fuchs, C., Prandelli, E., Schreier, M., & Dahl, D. W. (2013). All that is users might not be gold: How labeling products as user designed backfires in the context of luxury fashion brands. Journal of Marketing, 77(5), 75-91.
- Wilcox, K., Kim, H. M., & Sen, S. (2009). Why do consumers buy counterfeit luxury brands?. Journal of Marketing Research, 46(2), 247-259.
- Willems, K., Janssens, W., Swinnen, G., Brengman, M., Streukens, S., & Vancauteren, M. (2012). From Armani to Zara: Impression formation based on fashion store patronage. Journal of Business Research, 65(10), 1487-1494.
- Ward, M. K., & Dahl, D. W. (2014). Should the Devil Sell Prada? Retail Rejection Increases Aspiring Consumers' Desire for the Brand. Journal of Consumer Research, 41(3), 590-609.

Responsible for Module:
Fuchs, Christoph; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Luxury Marketing (WI001140) (lecture, 4 SWS)
Fuchs C [L], Caprioli S

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Electives from Operations and Supply Chain Management

Module Description

WIB19823: Advanced Topics in Operations & Supply Chain Management I

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	irregularly
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The assessment takes place in form of a written exam (120 min) at the end of the semester. In the exam students demonstrate that they are able to explain, discuss and critically evaluate specific concepts of quality management. Furthermore, they proof that they can apply the discussed quantitative approaches for operations and supply chain management, critically evaluate them and discuss the results. The answers involve own formulations, as well as calculations or mathematical modelling.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Knowledge of quantitative approaches to production and supply chain management. The modules "Management Science" and "Production and Logistics" or similar modules at other universitites are a prerequisite.

Content:
In this module, we address current topics in production and supply chain management on a graduate -level. This module covers the statistical basis for the design of experiments, product and process control (SPC) and reliability engineering. Quality assurance is examined, from the viewpoint of quality incorporated into product design, maintaining quality in production and procurement risk, using both quantitative problems and case studies and a hands-on Failure Mode and Effects Analysis exercise. Quality systems are introduced using an interactive Six-Sigma scenario. Quality management and the concept of using quality as a driver for change in an organization will help demonstrate the complexity of change management in an organization.

Intended Learning Outcomes:
By the end of this module, students will be able to:
- Review the key milestones in the integration of quality in products and business processes and understand the essential drivers and costs behind successful quality management.
- Estimate population quality from sample quality and make inferences about population parameters using confidence intervals, hypothesis testing, and goodness-of-fit tests.
- Explain the role of reliability in product design.
- Design process and product experiments and assess the effect of possible process failures on the product quality using the Failure Modes and Effects Analysis.
- Determine appropriate control limits in order to measure the capability of a process and understand how control charts are used in industry to monitor and improve quality.
- Perform process and equipment correlation to identify the root cause(s) of a process deviation.
- Compare methods managing supply risk and recommend solutions.
- Discuss the issues involved in managing for quality at different operational levels.
- Apply 6-Sigma principles to quality projects.

- Understand the 8-Disciplines methodology for problem analysis and problem solving.
- Analyse industry cases, applying the principles from the class, draw conclusions and present the results.

Teaching and Learning Methods:
The module consists of a lecture. Presentations by the lecturer are used to introduce the concepts and approaches. Case studies and in-class exercises are used to enable the students to work together and apply the concepts and quantitative approaches introduced in the course. They are encouraged to present and discuss their findings. Furthermore, students are encouraged to study the suggested literature.

Media:
Presentation slides
Technical papers, Case studies

Reading List:
A First Course in Quality Engineering: Integrating Statistical and Management Methods of Quality, K.S. Krishnamoorthi, CRC Press, 2012.

Responsible for Module:
Grunow, Martin; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Topics in Operations & Supply Chain Management I (WIB19823): (Quality Management) (lecture, 4 SWS)
Fedrow E, Ott H

For further information in this module, please click
campus.tum.de or here.

Module Description

WIB19837: Advanced Seminar Operations & Supply Chain Management: Production and Supply Chain Management

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The students write a research paper (max. 25 pages) relating to a specific topic within the focus of the module, in which they demonstrate that they can perform a small research project from a discussion of the relevant literature, analysis of problem and solution approaches to the application in examples or cases and the identification of directions for future research. A final presentation (30 minutes with ensuing Q&A) proves that students are able to present their work to a scientific audience in a precise, comprehensible and demonstrative way. Further information will be announced at the beginning of the semester.
Research paper and presentation will be graded as one contribution/examination, individual weighting is not applicable

Repeat Examination:
Next semester

(Recommended) Prerequisites:
It is expected that participants have an interest in practical problems of production planning, scheduling and logistics, and the quantitative modelling of business problems. Participants should be familiar with Operations Research (OR) techniques.

The modules "Management Science" and "Production and Logistics" or similar modules at other universitites are a prerequisite.

It is strongly advised that the participants have previously taken part in the module "Modelling, Optimization and Simulation in Operations Management" or similar modules at other universities.

Content:
The development of methods and tools for quantitative operations and supply chain management can be challenging. Different contextual factors often require the adaptation of tools and methods. In this module, a specific focus within operations and supply chain management will be studied, and its specific challenges in terms of developing quantitative decision support tools will be addressed.
After a general analysis of the focus area and its main challenges, we identify several specific operations and supply chain management requirements with regard to supporting decision-making in practice. Using different scientific papers, we investigate possibilities to deal with the specific challenges, and see how traditional production planning and control methods and concepts can be utilized in this context.

Intended Learning Outcomes:
At the end of the module the students will be able to:
- Review state-of-the-art in operations and supply chain management approaches related to the module focus.
- Apply literature findings and/or methodologies to examples or case studies.

- Critically evaluate the scientific contributions of the analyzed literature.
- Analyze problems and solution approaches for operations and supply chain management methods and tools in the context of the module focus.
- Develop ideas for future research in relation to the module focus.
- Adequately communicate and discuss scientific contributions and research findings within the focus of the module

Teaching and Learning Methods:
The module consists of a seminar. The contents is delivered through presentations by the students. The students improve the acquired knowledge by studying the suggested literature. The students will be supervised by the lecturer when they work on their topic.

Media:
Presentation slides
Technical papers

Reading List:
van Weele, Arjan J., Purchasing and Supply Chain Management, 2014

Research papers

Responsible for Module:
Grunow, Martin; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Seminar Operations & Supply Chain Management (WIB19837): (Process Industry) (seminar, 4 SWS)
Grunow M [L], Forel A, Grunow M, Pahr A, Schömig-Beißner M

For further information in this module, please click
campus.tum.de or here.

Electives from Finance and Accounting

Module Description

WIB23005: Advanced Seminar Finance & Accounting: Behavioral and Experimental Economics

Behavioral & Experimental Economics
TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Master	German	one semester	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The final grading is based on a research paper (70%) including a presentation (30%). The research paper (11-13 pages) is a written draft of a topic. The research paper will be written in teams, whereas single parts have to be assigned to single team members. By writing the research paper in teams, students demonstrate their ability within a team to manage resources, and deadlines through timely submission of the enumerated tasks. Students demonstrate that they are able to complete the tasks of their project in a team environment.
The research paper reveals the student's acquired abilities in identifying a reasonable and relevant research question in behavioral economics. Moreover, the research paper reveals the student's ability to develop research designs and analytical methods to examine the identified research question. Students show that they are able to interpret and to communicate the results.
Furthermore students are asked to present (20 minutes + 10 minutes discussion) their research paper in front of the class. By presenting their findings in front of the class, students proof that they are able to present the key aspects in a concise manner and that they are able to answer further questions on their presented findings.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Working knowledge of the mandatory basic business courses

Content:
The module offers participants an overview of current issues in behavioral economics and gives them the opportunity to examine one topic in more detail. The module may serve as starting point for further research, but also prepares participants for issues they are likely to face in their professional lives. Emphasis is put on aspects of experimental economics, social preferences, nudging, herding, and further phenomena of behavioral economics.

Intended Learning Outcomes:
After completing this module, students have an advanced knowledge of the module's core topic. They are able to identify theoretical and practical research questions and to develop research designs and analytical methods to examine the identified research question. In this context, they will compile a literature research and structure their work. Moreover, they are able to interpret and communicate the identified outcomes in an academically suitable way. Besides, the participants will be enabled to objectively analyze other seminar papers. They recognize potential conflicts in working together as a team and they reflect upon these considering varying conditions. They are able to integrate involved persons into the various tasks considering the group situation. Students are able to prepare a certain topic within a given time frame and to present it in clear and comprehensible manner to an

audience. They can react and respond to questions and suggestions relating to their subject area brought up by the audience during a discussion.

Teaching and Learning Methods:
This module is a seminar. Students will read, discuss and work with academic research papers. In the course of the module students will write a research paper and present their findings in class. In interactive discussions students react to questions and comments of their classmates. In this interactive seminar atmosphere students get a detailed insight to topics of behavioral economics.

Media:
Books, case descriptions, academic papers, presentation slides

Reading List:
Gneezy, U., & Rustichini, A. (2000). Pay enough or don't pay at all. The Quarterly Journal of Economics, 115(3), 791-810.

Frey, B. S., & Oberholzer-Gee, F. (1997). The cost of price incentives: An empirical analysis of motivation crowding-out. The American economic review, 87(4), 746-755.

Gneezy, U., & Rustichini, A. (2000). A fine is a price. The Journal of Legal Studies, 29(1), 1-17.

Ariely, D., Bracha, A., & Meier, S. (2009). Doing good or doing well? Image motivation and monetary incentives in behaving prosocially. American Economic Review, 99(1), 544-55.

Falk, A., & Fischbacher, U. (2006). A theory of reciprocity. Games and economic behavior, 54(2), 293-315.

Camerer, C., Babcock, L., Loewenstein, G., & Thaler, R. (1997). Labor supply of New York City cabdrivers: One day at a time. The Quarterly Journal of Economics, 112(2), 407-441.

Responsible for Module:
Mohnen, Alwine; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Seminar in Finance and Accounting (WIB23957): Behavioral and experimental economics. An introduction. (seminar, 4 SWS)
Mückenhausen V, Sittenthaler H

For further information in this module, please click
campus.tum.de or here.

Electives from Economics and Policy

Module Description

WIV05001: Advanced Seminar Economics & Policy: Economics of Innovation

Economics of Innovation
TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The students will work in small groups on one of five topics: Creation of knowledge, diffusion of knowledge, industry and macroeconomic aspects, intellectual property rights, innovation policy. The group work aims at 1) understanding the topic in depth and 2) presenting the most important insights from their topic to classmates. Moreover, the students will derive research gaps in the literature related to their topic and summarize both main insights and research gaps in a presentation (20-30 min. per person) to the class. By presenting in a team, students demonstrate their ability within a team to manage resources, and deadlines through timely submission of the enumerated tasks. Finally, they will submit an extended version of the presentation topic as a written research paper (8.000 to 10.000 words). By writing the research paper, students show their ability to work independently on solving complex scholarly problems related to the Economics of Innovation.
The final grade will be based on the written research paper with a weight of 80% and the presentation with a weight of 20%

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Familiarity with microeconomics

Content:
This module will provide students in-depth insights into the field of the Economics of Innovation. The module will discuss some of the prevailing models in the field of Industrial Organization dedicated to the analysis of the incentives and constraints to innovative activities (R&D activities) as well their relation with imitation, spillovers, firm size and market structure. The module also comprises a dynamic and knowledge-based view, introducing models involving the direct generation of new knowledge, the catching-up/falling behind dynamics of competition and the role played by market selection between innovative firms. The objective of is also to apply the acquired knowledge to selected topics in the field of innovation research. The students will be asked to write a research paper and to present their work in class.

Intended Learning Outcomes:
This module introduces the students to the main issues in the economics of innovation and advances their understanding of the core concepts and principles in the field. The ultimate objective to enhance both theoretical as well as an applied view on the topic enabling students to understand academic as well as public debate on questions related to the economics behind innovation and technological progress. Upon successful completion of this module, students will be therefore able (1) to identify and (2) conceptualize different important issues related to the Economics of Innovation. They (3) are able to identify gaps in the understanding of the focal topic and (4) developed suggestions for improving the understanding of the field. In addition, by presenting their topic to the

class, they will (5) enhance their presentation skills and by writing the research paper (6) their scientific writing skills. Through working in groups, the (6) students will work on their teamwork skills.

Teaching and Learning Methods:
The module is a seminar, in which the students will gain in-depth insights in the Economics of Innovation. The seminar will start with an introductory lecture, which will provide the bases for deeper study of the most relevant topics. The first phase will then concentrate on problem-based learning by reading relevant scientific literature and by discussing these articles in the group. In the second phase, students will individually elaborate a written paper as well as presentations in which they need to show their understanding of their focal topic as well as show their capability to identify research gaps in the discussed literature.

Media:

Reading List:
in general:
- Fagerberg, J., Mowery, D. and Nelson, R. R. (2010), Oxford Handbook of Innovation, Oxford: Oxford University Press
- Hall, B. H. and Rosenberg, N. (2010), Handbook of the Economics of Innovation, Oxford: Elsevier,
specific topics:
- Czarnitzki, D., Hottenrott, H. and Thorwarth, S. (2011) `Industrial research versus development investment - the implications of financial constraints', Cambridge Journal of Economics, 35, 527-544.

- Jaffe, A., Trajtenberg, M. and Henderson, R. (1993), `Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations', Quarterly Journal of Economics, 108, 577-598.
- Aghion, P., Dechezleprêtre, A., Hemous, D., Martin, R. and Van Reenen, J. (2016), `Carbon Taxes, Path Dependency and Directed Technical Change: Evidence from the Auto Industry', Journal of Political Economy, 124 (1).
- Gallini, N. und Scotchmer, S. (2002), `Intellectual Property: When Is It the Best Incentive System?', in: Jaffe et al. (Eds.), Innovation Policy and the Economy, MIT Press, 51-77.
- Lundval & Borrás (2005), `Science, technology, and innovation policy', in: Fagerberg, J., Mowery, D. and Nelson, R. R. (eds.), Oxford Handbook of Innovation, Oxford: Oxford University Press, 599-631.

Responsible for Module:
Hottenrott, Hanna; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Seminar in Economics & Policy (WIV05001): Economics of Innovation (seminar, 4 SWS)
Becker A, Römer K

For further information in this module, please click
campus.tum.de or here.

Module Description

WI001145: Energy Economics

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module entails a final written exam (120 minutes). The exam is a closed-book exam. By answering the questions students show their ability to differentiate and evaluate different market structures (at wholesale, transportation and retail level) in energy markets, e.g. in gas, coal, oil and power markets. Moreover students show their ability to discuss and apply theoretical and empirical methods to selected topics in energy markets. They show that they are able to analyze and assess recent energy market developments, such as for instance the energy transition, using the theoretical and empirical tools they have acquired.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Courses at TUM or elsewhere in microeconomics and introductory statistics or econometrics

Content:
This module covers the following topics:
Economics of energy markets
Analysis of producer strategies
Analysis of consumer behavior
Fundamentals of primary energy markets
Fundamentals of electricity markets
Analysis of network industries
Network regulation
Microeconomics
Game theory
Econometrics
Energy policy

Intended Learning Outcomes:
Students are able to explain and to differentiate different market structures (at wholesale, transportation and retail level) in energy markets, e.g. in gas, coal, oil and power markets. Furthermore, they are able to summarize and compare different strategies and behavior of producers and consumers, as well as on different forms of regulation of network industries. Students are also able to discuss and apply theoretical and empirical methods to selected topics in energy markets. With these tools student will thus be able to analyze and assess recent energy market developments, such as for instance the energy transition.

Teaching and Learning Methods:
The module is a lecture consisting of PowerPoint presentations so as to offer and explain to students all different topics covered in this module. A guest lecture is planned in which practitioners present on selected topics in energy markets. The exercise course comprises different problem sets that discuss problems covered during the lecture. Problem sets are solved individually or in group work and, supported by a presentation, derived and solved jointly with the tutor.

Media:
PowerPoint, exercise sheets, whiteboard, reader

Reading List:
Viscusi, W. et al. (2005): Economics of Regulation and Antitrust, MIT Press. Stoft, S. (2002): Power System Economics, Wiley. Selected journal articles.

Responsible for Module:
Schwenen, Sebastian; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Energy Economics (WI001145) (lecture, 2 SWS)
Schwenen S

Energy Economics - Exercise (WI001145) (exercise, 2 SWS)
Schwenen S, Bohland M

For further information in this module, please click
campus.tum.de or here.

Electives from Energy Markets

Technische Universität München

Module Description

WIB29001: Advanced Seminar Energy Markets

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module assessment consists of a research paper (80% of the grade) and a presentation (20% of the grade). Students have to author a research paper (approx. 25 pages) and to give a talk (approx. 60 minutes). By writing the research paper students show that they are able to reproduce the main insights and analyze complex issues in energy market relevant topics. Students demonstrate that they are able to conduct an individual research work and write a research paper using scientific methods. They are show that they are able to discuss and evaluate the advantages and drawbacks of new developments in in the area of energy markets.
By presenting their topic to the audience students demonstrate their communication competency in presenting scholarly work in a structured and systematic way to an audience. Furthermore students show that they are able to respond competently to any questions, suggestions or discussions brought by the audience and relate it to their subject area.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in energy markets

Content:
Key topics of the module may include:
- Current issues in energy market design
- Current issues in energy finance
- Applications of Operations Research to problems arising in the energy industry

Intended Learning Outcomes:
Upon successful completion of this module students will be able to reproduce the main insights and analyze complex issues in energy market relevant topics. Students will be able to conduct an individual research work and write a research paper on their own. Students will be able to discuss and evaluate the advantages and drawbacks of new developments in in the area of energy markets. Moreover students will be able to summarize specific issues and results to their essential core. They are able to prepare a certain topic within a given time frame and to present it in clear and comprehensible manner to an audience. They are able to respond competently to any questions, suggestions or discussions brought by the audience and relate it to their subject area

Teaching and Learning Methods:
The module is a seminar, in which the students will be assigned state-of-the-art research papers from the recent

literature. They are expected to prepare high-quality presentations and write-ups, reflecting their analyses, understanding and insights from reading the papers and related literature. The lecturer will provide guidance and advice all along, from the choice of the initial topic, to tips on reading original literature, on scientific writing, and on giving successful presentations

Media:
Power-Point slides

Reading List:
Bhattacharyya, S.: Energy Economics - Concepts, Issues, Markets and Governance. Springer 2011.

Responsible for Module:
Wozabal, David; Prof. Dr. rer. soc.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click
campus.tum.de or here.

Module Description

WI000946: Energy Markets I

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module entails a written exam at the end of the term (60 minutes). In order to optimally assess the students' achievements, the exam will consist of both, a multiple choice part (20%) and open questions (80%). In the multiple choice part students mainly show that they have professional knowledge regarding the characteristics of energy markets and that are able to classify it. With answering the open questions, students demonstrate their ability to solve problems as well as their ability of abstraction. Mathematical problems will be complemented by questions mainly aiming at economic intuition and thought patterns. Apart from a nun-programmable calculator no further tools or documents are permitted (closed book).

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in economics (competition theory), basics in corporate strategy (Porter etc.), ideally industrial economics (market power, oligopoly, barriers to market entry, transparency etc.) and trade (call, put, forward, future etc.)

Modules:
- Investment and Financial Management
- Mikroökonomik (Economics I)
- Industrieökonomik (Industrial Economics)
- Introduction to Strategy and Organization

Content:
This module gives a broad overview of energy markets and energy industries across all commodities. It covers the whole energy value chain from primary energy supply to energy consumption and presents the most relevant economic concepts.
Focus issues are forecasting energy demand, primary energy exploration and production, supply and demand curves / merit orders in different commodities, specific feature of energy markets, price formation and organised energy trading.
The module will be continued in summer with energy markets 2, focusing on renewables and grid regulation.

Intended Learning Outcomes:
After successful participation in the module, students possess a broad basic knowledge regarding the economic specifications of energy markets. Furthermore, students are able to solve energy related problems self-reliantly

using both, mathematical techniques as well as attained economic intuition.
Participants are moreover able to transfer economic principles on the special demands of energy markets.
After studying the provided literature, students are able to analyze and assess questions arising in terms of energy policy and recent developments in the fields of energy markets.
Participation in the module leads to a better understanding of energy markets and enables students to develop and evaluate business processes and models in the field of energy economics.
Taking part in the module enables students to competently advocate their views in discussions addressing energy economics and markets.

Teaching and Learning Methods:
The module consists of a lecture and an associated exercise course. The lecture provides basic knowledge about economical characteristics of energy markets via presentations. Students are encouraged to study the literature and discuss the provided topics. During the exercise courses, selected examples of problems arising in energy markets are discussed.

Media:
Slides and exercises

Reading List:
Erdmann, G. / Zweifel, P. (2010) Energy Economics: Theory and Applications; Springer 2017.
Ströbele, W. / Pfaffenberger, W. / Heuterkes, M. (2012) Energiewirtschaft - Einführung in Theorie und Politik; 3. Auflage; Oldenbourg 2012.
Bhattacharyya, S. (2011) Energy Economics - Concepts, Issues, Markets and Governance; Springer 2011.

Responsible for Module:
Wozabal, David; Prof. Dr. rer. soc.

Courses (Type of course, Weekly hours per semester), Instructor:
Energy Markets I (WI000946) (lecture, 2 SWS)
Bieberbach F, de Almeida Terca G

Energy Markets I - Exercise (WI000946) (exercise, 2 SWS)
Bohland M, de Almeida Terca G

For further information in this module, please click
campus.tum.de or here.

Electives from Life Sciences and Management

Module Description

WIB14002: Advanced Seminar Life Sciences & Management: Sustainable Entrepreneurship - Theoretical Foundations

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Master	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The grading is based on a research paper (max. 7.500 words). The students show that they are able to apply theoretical perspectives to the context of life sciences. Moreover, they develop an argument matching the concept of sustainable entrepreneurship as a promising approach for addressing complex sustainability issues in general and in the field of life sciences in particular. In the research paper students show that they can evaluate different approaches and develop their own ideas for life sciecne-related sustainable ventures.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Courses in entrepreneurship, corporate sustainability and/or sustainability marketing are recommended.

Content:
Whether it is tackling climate change, resource degradation or social inequalities - responding to sustainability issues constitutes the biggest challenge for businesses in the 21st century. Embracing a great range of industries including food, energy or textiles, the field of life sciences is a key area for sustainability. Since the production of these goods accounts for an extensive use of resources, there is great potential for effecting real improvements on a way towards more sustainable production and lifestyles. The course "Advanced Seminar Life Sciences and Management" will investigate this exciting and ongoing industrial transformation. It will deal with the following topics (all topics will be explained in general and then discussed in the context of life sciences in particular):

1) Introduction to Sustainability and Entrepreneurship
2) Sustainable Entrepreneurship
3) Opportunity Identification
4) Development of Double and Triple Bottom Line Solutions
5) Forming and Funding of New Sustainable Ventures
6) Market Entry
7) Sustainable Entrepreneurship and Life Sciences - Reflections and Discussion

Intended Learning Outcomes:
Upon successful completion of this module, students will be able to (1) summarize and (2) evaluate the socio-economic problems society is facing. They will (2) match the concept of sustainable entrepreneurship as a promising approach for addressing complex sustainability issues in general, and in the field of life sciences in particular. More specifically, students will (3) be able to identify the venture creation process from opportunity

identification to market entry in the context of sustainability and life sciences. In addition, participants will be able to (4) apply this knowlede to the field of life sciences. Finally, the students will be able to (5) critically evaluate case studies from the field of life sciences and to (6) create own ideas for sustainable ventures in this context.

Teaching and Learning Methods:
The module is a seminar which intends to familiarize the student with the relevant literature and follows an interactive course format with group work assignments and guest lectures. This is the appropriate format for this advanced level module because it encourages the students to go into further detail and to deal with the issues in an integral, interactive and independent way.

Media:
Presentations, slides, cases, links and further literature will be provided via www.moodle.tum.de

Reading List:
Muñoz, P., & Cohen, B. (2018). Sustainable entrepreneurship research: taking stock and looking ahead. Business Strategy and the Environment.

The module is based on key scientific papers on each topic. These form the basis for classroom discussions and are to be used for developing an argument in the reflection essay. All articles are provided as pdf files in TUM Moodle (https://www.moodle.tum.de).

Responsible for Module:
Belz, Frank-Martin; Prof. Dr. oec.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Seminar Life Sciences & Management (WIB14002): Sustainable Entrepreneurship - Theoretical Foundations (seminar, 4 SWS)
Belz F, Gimenez Jimenez D

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Module Description

WI000948: Food Economics

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students prove their achievement of learning outcomes in an oral exam of 30 minutes. The exam is designed to test whether students understand the discussed topics and publications in the field of food economics. Students are asked to describe and explain important trends and phenomena in food markets in Germany, Europe and the world in a meaningful and exact way. In the oral exam they also have to demonstrate their ability to analyze consumer and firm behavior in food markets based on economic theory and show that they are able to assess the effectiveness of food policy instruments. Additionally, students prove they can critically reflect on assumptions, methodology, results, and political and societal implications of research in food economics. An oral exam is the most suitable format to account for the discursive and reflective nature of the abilities examined.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
The course applies microeconomic theory to study questions of food demand and supply. Students should feel comfortable with the material in microeconomic courses at introductory level.

Content:
The course is intended to provide students with in-depth coverage of food economics with an emphasis on trends and phenomena of food markets, food labelling, food safety, food consumption, nutrition and food policy. Taking examples from these domains the course introduces a variety of economic models that are being used in food-economic research.

Intended Learning Outcomes:
At the end of the module, the students are able to (1) outline important trends and phenomena in food markets in Germany, Europe and the world, (2) analyse consumer and firm behavior in food markets based on economic theory, (3) assess the effectiveness of food policy instruments, (4) acquaint themselves with scientific literature in the area of food economics and discuss and evaluate crucial assumptions, choice of methodology and implications of results.

Teaching and Learning Methods:
The module is designed as an interactive lecture where both lecturers and students provide input for discussion. In order to set up a common basis for participants, lecturers present information on major features and trends on food markets and economic concepts used to analyze them. To familiarize themselves with economic research, students read selected journal articles from the field of agricultural and food economics and prepare a short presentation of 15 minutes and a short report of about 2 pages once per semester, summarising the main hypotheses, methods applied, results obtained and implications derived. Subsequent discussions in classroom on assumptions, limitations of data and methods, as well as on different ways to interprete results deepen students'

understanding of the potential and restrictions of research in food economics.

Media:
Slides, textbooks, journal articles, blackboard, collection of summaries of publications.

Reading List:
Lusk, J. L., Roosen, J, & Shogren, J. F. (eds.) (2011). The Oxford handbook of the economics of food consumption and policy. Oxford University Press: New York.
Additional references are provided in the course.

Responsible for Module:
Roosen, Jutta; Prof. Dr. Ph.D.

Courses (Type of course, Weekly hours per semester), Instructor:
Food Economics (WI000948) (lecture, 4 SWS)
Menapace L, Roosen J

For further information in this module, please click
campus.tum.de or here.

Mechanical Engineering

Module Description

MW1108: Engineering Mechanics for Technology Management [TM TUM BWL]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	135	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
In a 120-minute written examination, the understanding of the imparted principles and techniques of engineering mechanics is tested by application of them on various problems. These calculation problems are similar in the style to the exercises, where the students are intended to analyse, to systematically tackle and to solve the tasks included.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Good knowledge in applied mathematics. Recommended courses: "Mathematische Behandlung der Natur- und Wirtschaftswissenschaften 1+2" or "Höhere Mathematik"

Content:
Basic principles of statics, elastostatics and kinetics: force, moment (torque), equilibrium, method of sections, center of mass, energy and stability, stress and strain, elastic constitutive law, Mohr's circle, (Euler-Bernoulli) beam theory, area moments of inertia, kinematics and kinetics of particles, impact, vibrations.

Intended Learning Outcomes:
After successful participation the students are able to
- apply terminology, principles and techniques of engineering mechanics
- analyse, tackle and solve new problems out of the covered fields
- create self-dependently particular knowledge in the field of engineering mechanics on the basis of the conveyed fundamentals
- understand subsequent lectures at the faculty of mechanical engineering
- create a level of comunication with engineers in their daily professional life.

Teaching and Learning Methods:
The module consists of a lecture including exercises as well as a tutorial in small groups on a weekly basis. The lecture includes several teaching methods such as presentations, animations, short films and the usage of a blackboard. The current subject matter is repeated in tutorials and further examples are exercised. All teaching and exercise material as well as proposals for solutions and further information can be downloaded from the E-Learning platform.

Media:
Presentations, blackboard.

Documents via E-Learning platform.

Reading List:
Gross - Hauger - Schnell: Technische Mechanik 1, Springer Verlag
Gross - Hauger - Schröder - Wall: Technische Mechanik 2, Springer Verlag
Hauger - Schnell - Gross: Technische Mechanik 3, Springer Verlag
Wriggers - Nackenhorst - Beuermann - Spiess - Löhnert: Technische Mechanik kompakt, Springer-Vieweg-Verlag

Responsible for Module:
Werner, Ewald; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Engineering Mechanics for Technology Management - Exercises (exercise, 1 SWS)
Werner E [L], Krempaszky C (Jahn Y)

Engineering Mechanics for Technology Management (lecture, 2 SWS)
Werner E [L], Krempaszky C (Jahn Y)

Engineering Mechanics for Technology Management - Group Exercises (exercise, 2 SWS)
Werner E [L], Krempaszky C (Jahn Y)

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Electives from Mechanical Engineering (advanced)

Technische Universität München

Module Description

MW1921: Material Flow and Logistics [MFL]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students apply the lecture¿s contents in a written exam (duration: 90 minutes) with questions and calculation tasks. The only aid allowed is a non-programmable calculator. In this way, students demonstrate different abilities: to analyze logistics systems, logistics processes and logistics structures; to apply methods for planning of such structures; to understand the key functions of physical logistics.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
none

Content:
From a higher point of view, the module explains the tasks, aims, key indicators and impact factors of logistics. Common structures of production and distribution are presented along with according control strategies. Besides key functions of material flow-transportation, distribution/consolidation, storage, order picking and handling- methods to model material flow systems are taught, e. g. flow charts, graphs, material flow matrices and layouts. Methods to analyze system behavior complete the module; they comprise static dimensioning, event-discrete simulation, queuing theory and the concept of availability.
Additionally, the module contains the following contents:
Logistics systems: Design guidelines; logistical processes, functions, and structures; logistical networks; methods for planning logistical structures
Logistics management: Control and coordination in logistics systems, supply chain management, information management

Intended Learning Outcomes:
Having completed the module, students know about key tasks and aims of logistics. They are able to analyze logistics systems, logistical processes and logistical structures. Furthermore, they can apply methods to plan logistical structures and know means of control and coordination in logistics systems and concepts of information management.
In addition, students understand the key functions of physical logistics and are able to apply methods to depict material flow and to dimension and evaluate logistics systems.

Teaching and Learning Methods:
Contents are explained by lectures and by exemplary applications from industrial practice. Supporting the lectures,

students have access to a detailed collection of slides, exercises and sample solutions.
In tutorials, exercises demonstrate the applicability of the lectures¿ theoretical contents.
All documents and further information are accessible online and free via elearning. During office hours of scientific staff, individual questions and problems can be discussed.

Media:
Lectures: Talk with tablet and projector, board and overhead projector; printed scriptum (fee-based)
Online documents: Documents for exercises with sample solutions; scriptum (digital as PDF, free of charge)

Reading List:
Aggteleky, B.: Fabrikplanung: Werksentwicklung und Betriebsrationalisierung, Band 1-3. München, Wien: Hanser, 1987 (Band 1) und 1990 (Band 2 und 3)
Arnold, D.: Materialflusslehre. Braunschweig, Wiesbaden: Vieweg, 1998
Dangelmaier, W.: Fertigungsplanung. Düsseldorf: VDI-Verlag, 2001
Gudehus, T.: Logistik: Grundlagen, Strategien, Anwendungen. Berlin u.a.: Springer, 2005
Großeschallau, W.: Materialflussrechnung. Berlin u.a.: Springer, 1984
Kettner, H., Schmidt, J., Greim, H.-R.: Leitfaden der systematischen Fabrikplanung. München, Wien: Hanser, 1984
Jünemann, R.: Materialfluss und Logistik: Systemtechnische Grundlagen mit Praxisbeispielen. Berlin u.a.: Springer, 1998
Jünemann, R., Schmidt, T.: Materialflusssysteme: Systemtechnische Grundlagen. Berlin u.a.: Springer, 1999
Pfohl, H.-C.: Logistiksysteme: Betriebswirtschaftliche Grundlagen.
Berlin u.a.: Springer, 2004
VDI-Gesellschaft Fördertechnik Materialfluss Logistik (Hrsg.).
VDI-Handbuch Materialfluss und Fördertechnik: Band 1   8.
Düsseldorf: VDI-Verlag
Wildemann, H.: Logistik Prozessmanagement. München: TCW Transfer-Centrum, 2005
Wiendahl, H.-P.: Fertigungsregelung: Logistische Beherrschung von Fertigungsabläufen auf Basis des Trichtermodells. München, Wien: Hanser, 1997

Responsible for Module:
Fottner, Johannes; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Material Flow and Logistics (lecture, 2 SWS)
Vaskovits N [L], Fottner J

Material Flow and Logistics - Exercises (exercise, 1 SWS)
Vaskovits N [L], Fottner J

For further information in this module, please click
campus.tum.de or here.

Electives from Informatics

Module Description

IN0001: Introduction to Informatics 1

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	120	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Type of Assessment: exam (120 minutes)

The exam takes the form of 120 minutes written test. Questions allow to assess acquaintance with concepts of Informatics and programming, small programming tasks assess the ability to conceive appropriate algorithmic solutions and realize concurrent applications.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
Participants should attend IN0002 "Fundamentals of Programming (Exercises & Laboratory)" at the same time.

Content:
The module IN0001 is concerned with topics such as:
- Introduction
  ++ Basic notions: Problem - algorithm - program
  ++ Imperative programming constructs
- Syntax and semantics
  ++ Syntax of programming languages: regular expressions and contextfree grammers
  ++ Semantics of programs: control-flow graphs
- Basic data structures I
  ++ Numbers, strings, arrays
  ++ Insertion sort
- Recursion
  ++ Binary search
  ++ Patterns of recursion
- Basic data structures II
  ++ Objects, classes, methods
  ++ Lists, stacks, queues
- Object-oriented programming
  ++ Inheritance
  ++ Abstract classes and interfaces
  ++ Polymorphism
- Programming in the large (perspectives)
- Concurrency and Threads

Intended Learning Outcomes:
Upon successful completion of the module participants understand the essential concepts of computer science on a fundamental, practice-oriented, but scientific level.
Concepts of this kind are for example: Algorithms, syntax and semantics, as well as efficiency in terms of memory consumption or time.
Participants are then able to solve well-posed algorithmic problems and to implement basic distributed and concurrent applications in Java or a similar object-oriented language. They understand the underlying concepts and models and are therefore able to acquire skills in other imperative and object-oriented programming languages on their own.

Teaching and Learning Methods:
lecture, combined with experimental assessment of examples at the computer and evaluation of further readings

Media:
slide show, blackboard, online programming experiments, animations, lecture recording

Reading List:
Heinisch, Müller-Hofmann, Goll: Java als erste Programmiersprache, Teubner, 2007
Deitel, Harvey / Deitel, Paul: How to program Java Prentice-Hall, 2002
Flanagan, David: Java in a Nutshell O'Reilly, 2002
Bishop, Judith: Java gently Prentice-Hall, 2001
Eckel, Bruce: Thinking in Java Prentice-Hall, 2002

Responsible for Module:
Seidl, Helmut; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Introduction to Informatics 1 (IN0001) (lecture, 4 SWS)
Seidl H, Erhard J, Hagerer G, Kynast E

For further information in this module, please click
campus.tum.de or here.

Electives from Informatics (advanced)

Electives from Chemistry

Module Description

CH6202: General an Inorganic Chemistry

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	105	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsleistung wird schriftlich, in Form einer 90-minütigen Klausur erbracht. In dieser sollen die Studierenden nachweisen, dass sie in begrenzter Zeit und ohne Hilfsmittel konkrete Fragestellungen der Allgemeinen und Anorganischen Chemie (beispielsweise pH-Wert-Berechnung oder stoffchemisches Wissen) erkennen und diese lösen können. Die Prüfungsfragen gehen über den gesamten Modulstoff. Die Antworten erfordern entweder das im Modul erlernte Wissen oder daraus abgeleitete Berechnungen.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Keine Voraussetzungen notwendig.

Content:
In diesem Modul werden die grundlegenden Begriffe der Allgemeinen Chemie (Einheiten und Stoffgrößen der Chemie) behandelt. Nachfolgend erlernen die Studierenden, nach welchen Prinzipien und Methoden chemische Reaktionen, Rechnungen und Fragestellungen zu bearbeiten sind. Hierbei behandelt das Modul beispielsweise das Aufstellen von Reaktionsgleichungen, die Berechnungen von pH-Werten, von Einwaagen, von Konzentrationen sowie die Grundlagen der Elektrochemie. Neben den allgemeinen Aspekten der Chemie steht weiterhin die Anorganische Stoffchemie im Vordergrund des Moduls. Dabei werden überwiegend die Hauptgruppenelemente des Periodensystems behandelt. Den Studierenden wird stoffspezifisch das unterschiedliche Verhalten der Elemente vermittelt (Reaktivität von Elementen und Verbindungen). Es werden von jedem Element wichtige und anwendungsrelevante Verbindungen besprochen. Hierbei wird auch auf wichtige Teilaspekte für die Studierenden des Umweltingenieurwesens näher eingegangen (z.B.: Toxizität von Verbindungen, Treibhaus- und Umweltproblematik verschiedener Stoffe, Ansätze zur verbesserten Energieeffizienz).

Intended Learning Outcomes:
Nach der Teilnahme am Modul "Allgemeine und Anorganische Chemie" sind die Studierenden in der Lage, die grundlegenden Fachbegriffe der Chemie zu nennen und die wichtigsten Einheiten und Stoffgrößen zu erkennen, zu verstehen und selber anzuwenden. Weiterhin sind die Studierenden in der Lage, chemische Reaktionsgleichungen aufzustellen und mögliche Probleme in der Reaktivität der Stoffe zu erkennen und zu benennen und zugehörige Rechnungen (pH-Wert, Konzentration oder Löslichkeit) zu lösen. Die Studierenden verstehen die Grundlagen der Elektrochemie und sind mit der Stoffchemie der Hauptgruppenelemente des Periodensystems vertraut. Die Studierenden wissen, dass Elemente unterschiedliche Eigenschaften besitzen und, in Verbindungen, unterschiedlich reagieren. Darüber hinaus sind die Studierenden nach der Teilnahme am Modul in der Lage, die Prinzipien und Methoden der Chemie, welche sich überwiegend in den analytischen Denkweisen und den angewandten Rechnungen widerspiegeln, zu verstehen und anzuwenden. Weiterhin entwickeln die

Studierenden einen analytischen Blick für aktuelle umweltpolitische Probleme (z. B. Feinstaubdiskussion, Treibhaus- und Umweltproblematik verschiedener Stoffe, Ansätze zur verbesserten Energieeffizienz).

Teaching and Learning Methods:
Das Modul besteht aus einer Vorlesung (2 SWS) mit begleitender Übung (1 SWS). Die Inhalte des Moduls werden in der Vorlesung im Vortrag und durch Präsentationen vermittelt. Hierbei werden die Studierenden über die Grundlagen der Chemie zu weiterführenden Inhalten herangeführt. Der Lernstoff wird stufenweise vermittelt, sodass die Studierenden auf dem zuvor erlerntem Wissen aufbauen können. Zur Festigung der Lernergebnisse werden in der begleitenden Übung Aufgaben bearbeitet, die zeitgleich zur inhaltlichen Auseinandersetzung mit den Themen und zum Studium weiterführender Literatur anregen sollen. Des Weiteren dienen ausgegebene Hausaufgabe zur freiwilligen Festigung des Lernstoffs, bzw. zur erweiterten Übung der Modulinhalte.

Media:
Vortrag, Präsentationen, Tafelanschrieb, Übungsaufgaben

Reading List:
Mortimer/Mu¿ller: Chemie, Das Basiswissen der Chemie, 12. Auflage, 2015 (Thieme)
Riedl/Meyer: Allgemeine und Anorganische Chemie, 11. Auflage, 2013 (de Gruyter)

Responsible for Module:
Plank, Johann Peter; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
English title will be supplied (exercise, 1 SWS)
Plank J, Theobald M

English title will be supplied (lecture, 2 SWS)
Plank J, Theobald M

For further information in this module, please click
campus.tum.de or here.

Electives from Chemistry (advanced)

Technische Universität München

Module Description

CH1019: Laboratory Course in Chemical Engineering

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	German	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
3	90	60	30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Modulleistung besteht ausschließlich aus einer Laborleistung. Die Laborleistung wird in Form eines Laborpraktikums erbracht und besteht aus der gleichgewichteten Mittelung der benoteten Ergebnisse der Einzelversuche aus dem Bereich der Technischen Chemie und Makromolekularen Chemie. Die Bewertung jedes Pflichtversuchs stützt sich auf folgende Beiträge: Einem Antestat, die Versuchsdurchführung, einem Abtestat und einem schriftlichen Bericht zum Versuch (Protokoll als Hausarbeit). Im Antestat weisen die Studierenden nach, dass Sie die theoretischen grundlegenden Aspekte zu den Versuchen verstanden haben und sich ausreichend für die Versuchsdurchführung vorbereitet haben. Dies ist notwendig, um die Sicherheitsaspekte beim Arbeiten in einem Labor sicherzustellen. Während der Versuchsdurchführung erlernen die Studierenden grundlegende Konzepte der Technischen Chemie und bekommen dadurch einen Überblick über die Zusammenhänge zu chemisch relevanten Themen. Die Studierenden können am Ende des Moduls grundlegende Konzepte anwenden um chemische Problemstellungen zu bearbeiten und verfügen über eine breite Stoffkenntnis. In den Berichten zeigen die Studierenden, dass sie die jeweiligen Versuche protokollieren, sie selbstständig auswerten und die eigenen Ergebnisse kritisch bewerten können. Hierzu zählt auch die Durchführung von Fehlerrechnungen.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Module: "Grundlagen der Technischen Chemie", "Reaktionstechnik und Katalyse für TUM-BWL" und "Angewandte Technische Chemie" (Makromolekulare Chemie)

Content:
Dieses Praktikum besteht aus zwei Teilen:
1. Teil Technische Chemie bei Dr. Erika Ember
Es wird ein Pflichtversuch (Transportlimitierung bei der Katalyse an festen Katalysatoren - Versuch A4) in 3er Gruppen durchgeführt. Es kann zusätzlich ein Wahlversuch (Stabilitätsverhalten eines kontinuierlich betriebenen Rührkesselreaktor - Versuch C4) durchgeführt werden.

2. Teil Makromolekulare Chemie bei Dr. Carsten Troll
Hier werden zwei Einzelversuche in 3er Gruppen durchgeführt. Die borhaltige Polysiloxane (Herstellung des "Hüpfenden Siliconkitts", nichtnewtonsche Flüssigkeit) und die Epoxidharze (Wie können die Eigenschaften von Epoxidharzen gezielt eingestellt werden?).

Intended Learning Outcomes:
Im Praktikum sollen die Studierenden das selbstständige experimentelle Arbeiten, die Auswertung von Messdaten und die wissenschaftliche Darstellung der Messergebnisse erlernen. Nach erfolgreicher Teilnahme an

dem Modul "Praktikum Technische Chemie für TUM-BWL" erinnern sich die Studierenden an diverse spezifische Versuchsaufbauten, -durchführungen und -auswertungen der Technischen Chemie und Makromolekularen Chemie. Speziell kennen die Studierenden diverse Transportphänomene in der Chemie, beispielsweise die Transportlimitierung bei der Katalyse an festen Katalysatoren. Im Teil Makromolekulare Chemie synthetisieren die Studierenden verschiedene Polymere und untersuchen deren mechanischen Eigenschaften. Sie sind in der Lage mikrostrukturelle Besonderheiten mit den resultierenden mechanischen Eigenschaften zu vernüpfen und die resultierenden Zusammenhänge zu verstehen. Sie können das zuvor erlente theoretische Wissen in der Praxis anwenden und auf weitere Problemstellungen übertragen.

Teaching and Learning Methods:
Das Modul besteht aus einem Praktikum (2 SWS), in welchem von den Studierenden Einzelversuche an speziell entworfenen Versuchsständen unter Anleitung eines Betreuers durchgeführt werden. Vor dem jeweiligen Versuch wird in einem Gespräch in die Handhabung des Versuchsaufbaus eingeführt. Die TeilnehmerInnen absolvieren das Praktikum in der Regel in Dreiergruppen.

Media:
Zu den Einzelversuchen werden Unterlagen (Skript zu Theorie und Messprogramm) zur Verfügung gestellt.

Reading List:
- F. Patat, K. Kirchner, Praktikum der Technischen Chemie
- P.W. Atkins, Physical Chemistry

Responsible for Module:
Hinrichsen, Kai-Olaf Martin; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
English title will be supplied (practical training, 2 SWS)
Lercher J, Rieger B, Hinrichsen K, Troll C

For further information in this module, please click
campus.tum.de or here.

Electives from Electrical Engineering and Information Technology

Module Description

EI29821: Principles of Information Engineering

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Die Prüfungsleistung wird in Form einer Klausur (75 min) erbracht. In dieser soll nachgewiesen werden, dass in begrenzter Zeit und ohne Hilfsmittel in den Veranstaltungen des Moduls behandelte Grundaufgaben der Informationstechnik gelöst werden können. Mit den Prüfungsaufgaben wird das Erreichen der angestrebten Lernergebnisse des Moduls geprüft. Die Prüfungsfragen gehen über den gesamten Vorlesungsstoff.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Grundlegende (Schul-)kenntnisse der Algebra und der Integralrechnung.

Content:
Klassifizierung von Signalen, Abgrenzung Datenverarbeitung - Datenübertragung. Grundlegende Elemente der Datenverarbeitung: Beschreibung von Schaltnetzen, Boolesche Algebra, Schaltfunktionen, disjunktive und konjunktive Normalform, Minimierung von Schaltfunktionen. Zahlensysteme, Rechnen im Dualsystem. Schaltwerke. Maschinenprogrammierung. Grundlegende Elemente der Datenübertragung: deterministische und stochastische Signale. Periodische Signale, reelle und komplexe Darstellung, Fourier-Reihenentwicklung. A/D und D/A-Umsetzung. Grundlage statistischer Methoden, Zufallsgrößen, Wahrscheinlichkeitsdichte, Verteilungsfunktionen und Momente. Berechnung der Bitfehlerwahrscheinlichkeit digitaler Übertragungssysteme. Einfache Codes zur Fehlerkorrektur.

Intended Learning Outcomes:
Durch die Teilnahme an den Modulveranstaltungen erhalten die Studierenden Grundkenntnisse in ausgewählten Themenbereichen der Informationstechnik. Sie haben die Fähigkeit, auf den behandelten Themenfeldern grundlegende Aufgaben der Schaltungsentwicklung und Schaltungs- bzw. Signalanalyse durchzuführen.

Teaching and Learning Methods:
Das Modul besteht aus einer Vorlesung (2SWS) und einer Übung (2SWS). In der Vorlesung wird der Lernstoff mittels PowerPoint-Präsentation vermittelt. Details und Beispiele werden an der Tafel präsentiert. In der Übung werden konkrete Aufgabe und Beispiele an der Tafel vorgerechnet.
Als Lernmethode wird zusätzlich zu den individuellen Methoden des Studierenden eine vertiefende Wissensbildung durch mehrmaliges Aufgabenrechnen in Übungen angestrebt.

Als Lehrmethode wird in der Vorlesungen und Übungen Frontalunterricht gehalten, in den Übungen auch Arbeitsunterricht (Aufgaben rechnen).

Media:
Folgende Medienformen finden Verwendung:
- Präsentationen
- Skript
- Übungsaufgaben mit Lösungen als Download im Internet

Reading List:
Skriptum zur Vorlesung, erhältlich in FSEI

Responsible for Module:
Hanik, Norbert; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Grundlagen der Informationstechnik (LB) (lecture, 4 SWS)
Hanik N, Kernetzky K

For further information in this module, please click
campus.tum.de or here.

Electives fromInformation Technology and Electronics (advanced)

Module Description

EI0631: Media Technology

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The type of examination is a written exam with 90 minutes duration. Students solve selected problems based on the introduced concepts and equations. Additionally, they answer questions about the lecture content and explain in their own words selected methods from the lecture. Students are allowed to bring 4 pages of handwritten notes and a non-programmable calculator.
Matlab assignments with voluntary participation are offered during the semester and can be used to improve the final grade of the course.

The final grade is composed of the following elements:
- 100% final exam

Successful completion of the Matlab assignments leads to a bonus of 0.3 on the final grade in case the final is passed. The Matlab assignments are successfully completed if at least an average of 65% is obtained when submitting the solutions to the module tutor.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Higher Mathematics, Linear Algebra, Signal Processing

Following modules should have been accomplished before participation:
- Signals
- Introduction to signal processing
- Systems

Content:
image construction camera models and coordinates, mapping from world to pixel coordinates, camera calibration, sterea camera systems, image synthesis,the rasterization of geometric primitives, geometric scene description using polygon meshes and parametric surfaces, illumination of surfaces, shading, texture mapping, rendering pipeline, analog video, color TV systems, digital video, format conversion

Intended Learning Outcomes:
Upon completion of the module, students are able to:
- characterize the fundamental principles of information retrieval using the example of text and image search and to evaluate the performance of different approaches
- develop a simple system for media search and to evaluate its performance
- describe the creation of images and mathematically compute the mapping between world coordinates and pixel

coordinates for single and stereo camera systems
- perform external and internal camera calibration and analyze the calibration error
- describe the fundamental principles of image synthesis including the rasterization of geometric primitives, geometric scene description using polygon meshes and parametric surfaces, illumination of surfaces, shading, texture mapping
- describe the basic steps of the rendering pipeline and evaluate it for simple scenes with point light sources
- characterize analog and digital video and to analyze their differences
- compute the influence of phase errors for color TV systems NTSC, SECAM, and PAL.
- perform the conversion between different formats for digital TV signals

Teaching and Learning Methods:
Teaching and learning methods consist of presentations during the lecture and the exercises. Moreover, the students will improve their knowledge by use of scientific literature and implement selected concepts of the lecture using matlab during the voluntary project during the semester.

Media:
Following forms of media are applied:
- presentations
- script
- exercises with solution (downloadable from the internet)

Reading List:
Following literature is recommended:
- R. Steinmetz, Multimedia-Technology Springer-Verlag, 3. überarb. Auflage, 2000.
- Foley et al, Computer Graphics: Principles and Practice, Addison Wesley, zweite Auflage, 1995.
- Manning et al., Introduction to Information Retrieval, Cambridge University Press, 2008.
- U. Schmidt, Professionelle Videotechnik, Springer-Verlag, 2000.

Responsible for Module:
Steinbach, Eckehard; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Media Technology (lecture with integrated exercises, 4 SWS)
Steinbach E, Adam M

For further information in this module, please click
campus.tum.de or here.

Electives from Power Engineering (advanced)

Module Description

EI0611: Basics of Electrical Energy Storage

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	German	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Im Rahmen einer 60 minütigen schriftlichen Klausur wird durch das Beantworten von Fragen und Berechnungen an vorgegebenen Speichersystemen überprüft, ob die Studierenden in der Lage sind Speichertechnologien wiederzugeben und anhand eines universellen Speichermodells zu beschreiben.

Während des Semesters sollen fachliche Vertiefungen durch Lesen von Fachartikeln erfolgen. Diese zu lesenden Artikel werden in der Vorlesung diskutiert und sind auch prüfungsrelevant.

Die Endnote setzt sich aus folgenden Prüfungselementen zusammen:
- 100 % Abschlussklausur

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Keine speziellen Anforderungen

Content:
Die Vorlesung vermittelt einen Einblick in die Grundlagen und die Funktionsweise von elektrischen Energiespeichern.
- Einführung, Begriffe, Definitionen
- Abstraktes Speichermodell
- Grundlagen kinetische Speicher (Schwungrad)
- Grundlagen weitere mechanische Speicher (Druckluft, Pumpspeichersystem)
- Grundlagen direkte elektrische Speicher
- Grundlagen Batteriespeicher
- Grundlagen Gasspeicher (Elektrolyse, Methanisierung ...)

Intended Learning Outcomes:
Nach erfolgreichem Abschluss des Moduls ist der Hörer in der Lage unterschiedlichen Speichertechnologien und darauf basierende Speichersysteme zu berechnen und zu bewerten, einschließlich eventueller Wandlersysteme, die notwendig sind. Anhand einer abstrakten Betrachtung mit einem universellen Speichermodell vermögen sie eine technologieunabhängige Betrachtung einzusetzen.

Teaching and Learning Methods:
Als Lehrmethode wird in der Vorlesung Frontalunterricht, ergänzt durch Gruppendiskussionen, verwendet. Ferner sollen Exponate zur Veranschaulichung eingesetzt werden und einige Zusammenhänge werde auch mittels Animationen gezeigt.

Als Lernmethode wird zusätzlich zu den individuellen Methoden des Studierenden eine vertiefende Wissensbildung durch anschauliche Fallstudienbetrachtungen angestrebt.

Media:
Folgende Medienformen finden Verwendung:
- Präsentationen mit Laptop und Beamer
- Tafelanschrieb
- Diskussionen zu Fachaufsätzen und aktuellen Themen, wie Speicher in der Elektromobilität und Speicher für die Enmergiewende.

Reading List:
Allgemeine Literatur wird in der Vorlesung bekannt gegeben.
Es werden verschiednene Zeitschriftenbeiträge online zur verfügung gestellt, die dann auch in der Vorlesung diskutiert werden.

Responsible for Module:
Jossen, Andreas; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:
Basics of Electrical Energy Storage (lecture, 3 SWS)
Jossen A, Kucevic D

Basics of Electrical Energy Storage (exercise, 1 SWS)
Jossen A, Kucevic D

For further information in this module, please click
campus.tum.de or here.

Electives from Computer Engineering

Module Description

EI10001: Principles of Information Engineering [PIE]

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Bachelor	English	one semester	summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	135	45

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The module examination is based on a written exam (75 minutes) which contains questions to asses the students' knowledge about the technical systems, e.g. information transmission systems, and their theoretical background, e.g. design priciples, short mathematical problems to assess the students' mastering of the practiced mathematical concepts, and conceptual questions (e.g., about design principles or fundamental limitations) to assess the further intended learning outcomes. Up to 20% of the examination can be conducted in the form of multiple choice questions.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
The following module should be successfully completed prior to participation: MA9711 Mathematics in Natural and Economic Science 1.
The following module is recommended to be attended in parallel (if not already attended earlier): MA9712 Statistics for BWL.

Content:
* Fundamentals:
- Elements of Stochastic Modeling and Analysis
- Signals (analog/digital, deterministic/stochastic, real/complex)
- The Frequency Domain (Fourier transform, spectrum and bandwidth, sampling theorem)
- Information Theory (fundamentals, source coding, channel coding, channel capacity)
* Information Transmission and Storage Systems:
- Elements of Data Transmission (transmission chain, filtering, modulation, detection)
- Communication Systems (real systems compared to theory, channel models, performance criteria, comparison to data storage, current trends)
- Communication Networks (network structures, interference, broadcast and multiple access, multihop and relaying, abstraction layers, network planning)
* Elements of Information Processing
- Data Processing Devices (abstraction layers, real systems compared to theory, digital processing, algorithms and complexity)
- Data Acquisition and Analysis (sampling and quantization, information and noise modeling, feature extraction, machine learning)
- Security Aspects (reliability, security, secrecy, encryption)

Intended Learning Outcomes:
After attending the module, the students:
- can describe the main principles of operation of information transmission systems and networks as well as of data processing devices and methods
- are familiar with fundamental design principles of such systems and understand why existing systems are designed the way they are
- have an overview of the underlying physical and mathematical principles and can distinguish fundamental limitations from technological constraints
- have learned to take an engineering perspective on information transmission and processing tasks (e.g., by structuring a system into building blocks and abstraction layers)
- know the main mathematical methods relevant for this field of engineering and are able to apply a selection of these methods to example problems

Teaching and Learning Methods:
The module is designed for non-engineering students (in particular students in Management and Technology) who aim at understanding the fundamental principles and concepts of modern information transmission and processing. It consists of lectures, tutorials, and self-study.

In the lectures, both theoretical backgrounds and technical implementations are introduced and discussed. Mathematical concepts are introduced and explained as far as it is necessary for understanding the technical systems. The relevance of each of the considered topics is motivated by, e.g., press articles, teaser questions, or examples from daily life, and an additional reflexion at the end of each topic unit aims at conveying the engineering perspective on the considered problems and systems. New concepts are presented in a teacher-centered style and discussed in an interactive manner.

The aim of the tutorials is to repeatedly practice the application of the mathematical concepts as well as the ability to answer conceptual questions about the subject. The tutorials are held in a student-centered way, and problem sheets are provided.

Throughout the semester, short reading assignments may be given to the students, e.g., as an introduction to a new topic. In addition, the students are expected to recapitulate the lecture contents and to individually practice the exercises.

Media:
- Slide Presentations
- Blackboard (e.g., for mathematical details)
- Supporting documents (e.g., news articles, scientific publications) as downloads (reading assignments)
- Problem sheets as downloads

Reading List:
Recommendations and downloads are provided during the course separately for each topic.

Responsible for Module:
Utschick, Wolfgang; Prof. Dr.-Ing.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Electives from Computer Engineering (advanced)

Technische Universität München

Module Description

IN2028: Business Analytics

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination takes the form of a written 90 minutes test, in which students solve problems to prove they understand the functioning of various methods and their assumptions. Participants demonstrate their ability to interpret the results of different statistical processes and to evaluate their model quality in the exercises. The correct responses require the independent construction of analytical solutions with the help of techniques learned in the module.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
IN0007 Fundamentals of Algorithms and Data Structures, IN0008 Fundamentals of Databases

Content:
Inferential Statistics, Multi-linear Regression, Logistic and Poisson Regression, Naïve Bayes and Bayes Nets, Decision Tree Classifiers, Data Preparation, Evaluation of Classifiers and Learning Theory, Ensemble Methods and Clustering, Dimensionality Reduction, Association Rules

Intended Learning Outcomes:
After successful completion of the module students are familiarized with common methods of classification, numerical prediction and Clustering. They know the assumptions of these processes and understand their functioning, as well as their typical operational applications. Participants are able to analyze data sets with the programming language R and can interpret the results of these analyses.

Teaching and Learning Methods:
The module consists of a lecture and a content-aligned tutorial. The lecturer presents the content of the module, parts of the corresponding literature and application examples from practice interactively. Students are accustomed with the statistical methods and learn to differentiate their usage. In the tutorial participants solve exercises in supervised single person work and evaluate the respective Data Mining techniques. In addition, they practice to solve common problems by approaching empirical case studies in teamwork together with their tutor. Students learn to develop their own, data-based solution concepts, and to constructively criticize their own work. Participants particularly train their technical data mining abilities at the PC with the data processing software R.

Media:
Script, exercise sheets, PowerPoint, PC and E-Learning platform

Reading List:
- Ian Witten, Eibe Frank: Data Mining: Practical Machine Learning Tools and Techniques, 3rd ed., Morgan Kauffman, 2011 (E-Book http://proquest.tech.safaribooksonline.de.eaccess.ub.tum.de/9780123748560)
- Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirnai: An Introduction to Statistical Learning, Springer, 2014 (E-Book http://www-bcf.usc.edu/%7Egareth/ISL/)
- Jay Kearns: Introduction to Probability and Statistics using R, 2010 (E-Book http://cran.r-project.org/web/packages/IPSUR/vignettes/IPSUR.pdf)

Responsible for Module:
Bichler, Martin; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Business Analytics, Exercise Session (IN2028) (exercise, 2 SWS)
Bichler M [L], Heidekrüger S, Sutterer P

Business Analytics (IN2028) (lecture, 2 SWS)
Bichler M

For further information in this module, please click
campus.tum.de or here.

Electives from Industrial Engineering

Module Description

IN2028: Business Analytics

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
5	150	90	60

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The examination takes the form of a written 90 minutes test, in which students solve problems to prove they understand the functioning of various methods and their assumptions. Participants demonstrate their ability to interpret the results of different statistical processes and to evaluate their model quality in the exercises. The correct responses require the independent construction of analytical solutions with the help of techniques learned in the module.

Repeat Examination:
End of Semester

(Recommended) Prerequisites:
IN0007 Fundamentals of Algorithms and Data Structures, IN0008 Fundamentals of Databases

Content:
Inferential Statistics, Multi-linear Regression, Logistic and Poisson Regression, Naïve Bayes and Bayes Nets, Decision Tree Classifiers, Data Preparation, Evaluation of Classifiers and Learning Theory, Ensemble Methods and Clustering, Dimensionality Reduction, Association Rules

Intended Learning Outcomes:
After successful completion of the module students are familiarized with common methods of classification, numerical prediction and Clustering. They know the assumptions of these processes and understand their functioning, as well as their typical operational applications. Participants are able to analyze data sets with the programming language R and can interpret the results of these analyses.

Teaching and Learning Methods:
The module consists of a lecture and a content-aligned tutorial. The lecturer presents the content of the module, parts of the corresponding literature and application examples from practice interactively. Students are accustomed with the statistical methods and learn to differentiate their usage. In the tutorial participants solve exercises in supervised single person work and evaluate the respective Data Mining techniques. In addition, they practice to solve common problems by approaching empirical case studies in teamwork together with their tutor. Students learn to develop their own, data-based solution concepts, and to constructively criticize their own work. Participants particularly train their technical data mining abilities at the PC with the data processing software R.

Media:
Script, exercise sheets, PowerPoint, PC and E-Learning platform

Reading List:
- Ian Witten, Eibe Frank: Data Mining: Practical Machine Learning Tools and Techniques, 3rd ed., Morgan Kauffman, 2011 (E-Book http://proquest.tech.safaribooksonline.de.eaccess.ub.tum.de/9780123748560)
- Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirnai: An Introduction to Statistical Learning, Springer, 2014 (E-Book http://www-bcf.usc.edu/%7Egareth/ISL/)
- Jay Kearns: Introduction to Probability and Statistics using R, 2010 (E-Book http://cran.r-project.org/web/packages/IPSUR/vignettes/IPSUR.pdf)

Responsible for Module:
Bichler, Martin; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Business Analytics, Exercise Session (IN2028) (exercise, 2 SWS)
Bichler M [L], Heidekrüger S, Sutterer P

Business Analytics (IN2028) (lecture, 2 SWS)
Bichler M

For further information in this module, please click
campus.tum.de or here.

Technische Universität München

Other Electives in Management and/or Technology

Ethics (max. 2 exam in 2 different modules can be counted)

Project Studies

Module Description

WI900685: Project Studies (Master in Management and Technology)

TUM School of Management

Module Level:	**Language:**	**Duration:**	**Frequency:**
Master	German/English	one semester	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
12	360	330	30

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Grading is based on a project work. The project work consists of a written project report (40-50 pages) and of a final presentation (30 minutes). A student team of 2-5 students works on a specific problem set within a company or any other similar institution. The team runs through several project stages: problem definition, division of work/tasks, decision making processes, and realization. In that the students show that they can develop appropriate strategies to cope the set of problems. They show that they are able to compose the state of research. In addition they demonstrate their ability to develop their own specific approach for a solution based on scientific knowledge as well as methodical skills. Students demonstrate their ability within a team to manage resources, and deadlines through timely submission of the enumerated tasks. Students demonstrate that they are able to complete the tasks of their project in a team environment. By presenting their project report students show their ability to summarize and communicate the evolvement of the project in a clear, well-structured and convincing manner to the supervisors from the company as well as the university. Additionally they show that they are able to respond competently to questions and discussions related to their suggested solutions brought by the audience.
Grading will especially take into account the overall working outcome of the project with respect to the initial problem set, the selection and application of the chosen methodology as well as the analyses and discussion of the main findings. The project work is set up in a way which enables the identification and evaluation of each student's individual contribution to the project's success.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Basic knowledge in Business Administration

Content:
The project study consists of a specific problem statement or challenge which a company or any other similar institution is confronted with. This challenge may have a research related or practical character.
- Analyzing potential sales volumina of a new market,
- identifying potential optimization actions regarding a supply chain,
- creating a financing concept for a company,
- the explanation of problems out of the logistic sector and the development of appropriate optimization solutions,
- the development of specific Use-Cases for new electronic payment procedures and deduction of appropriate product specifications,
- the capturing and processing of KPIs in controlling and the development of recommended actions,
- or the development and explanation of a marketing strategy and the development of recommendations for implementing them in the given market- or company environment
are just a few examples of what may be subject of a project study. The project study and its findings regarding the outlined problem set are based on students' academic knowledge gained through their study programs.

Intended Learning Outcomes:
After successful participation in the module students are able work on a project in a systematic and academic manner. They can contribute an own part to a team's work output. Students are able to exchange in a professional and academic manner within a team. They show that they are able to integrate involved persons into the various tasks considering the group situation. Furthermore the students conduct solution processes through their constructive and conceptual acting in a team. They can make this contribution in a time limited environment. The students can capture and identify problem sets. Furthermore they can analyze appropriate methodologies for problem solving. They are able to infer the appropriate methodologies and to adapt these. On this basis they can develop analytical solution finding. Finally they can and evaluate the developed solutions regarding the problem set. Finally students are able to summarize and clearly and convincingly communicate the evolvement of their project and the developed solutions to an audience of professionals and academics.

Teaching and Learning Methods:
The team-based development (2-5 students) of the project solution encourages the students to deal soundly with an academic or practical subject based on their previously acquired academic knowledge. Team work is particularly suitable for tackling problem sets and writing a report, for developing constructive critique to others and for implementing appropriate solutions to these critiques. The project may happen at the premises of the respective company/institution or from a remote location. They are able to communicate the evolvement of the project by composing a project report and preparing a presentation of their solutions to the supervisors from the company as well as the university. The project is supervised jointly by mentors from the respective company/institution and the professor of the TUM School of Management. With regards to content the project study takes an approximate time of three month.

Media:
literature, presentations

Reading List:
Project Management Institute (2013): A Guide to the Project Management Body of Knowledge (PMBOK® Guide) - Fifth Edition
Wilson, A. M., Jones, R., Miller, K., & Pentecost, R. (2009). Marketing research: An integrated approach. Pearson Australia.
Further specific literature based on the topic

Responsible for Module:
Fuchs, Christoph; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click
campus.tum.de or here.

Advanced International Experience

Technische Universität München

Module Description

WI001181: Advanced International Experience

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	English	one semester	winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
6	180	180	0

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Students have to pass a written single-choice exam. The module examination consists of a written 90-minute single-choice exam. The test examine deeper knowledge of the meaning of culture, cultural differences and resulting difficulties. Tasks which refer to scientific cultural concepts verify that students are able to distinguish between different cultural dimensions and standards, for example the cultural dimensions of Geert Hofstede's concept. Tasks which refer to different management styles and working cultures examine that students are able to analyse how different cultural backgrounds influence working in an international business context, for example a Western Management style. Tasks which refer to country-specific cultural differences proof that students are able to interpret critical intercultural situations correctly and offer adequate behavioral patterns. Tasks which refer to intercultural communication check that students are able to distinguish between different communication styles influenced by culture and know how to communicate adequately with members of different cultures, for example cultures with a direct communication style.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Students have to complete a stay abroad relevant to their subject of studies before they can be admitted to the module. In general, for this purpose international study experience, practical training abroad as well as the completion of a project study or master's thesis is accepted.
(Details see:
https://www.wi.tum.de/programs/master-in-management/downloads/
https://www.wi.tum.de/programs/master-consumer-affairs/downloads/
https://www.wi.tum.de/programs/master-mt/downloads/)

Content:
This module gives an introduction to basic theoretical knowledge in scientific conceptualisation of culture, cultural differences and difficulties as well as their overcoming. During the module various scientific definitions of culture and different scientific approaches of cultural dimensions are outlined. By means of selected cultural characteristics and practical examples it is explained how to deal with different matters occurring when people with different cultural background interact. Additionally, different management styles in view of different cultures are declared. During the module explanatory approaches to difficulties which result from different cultural backgrounds in an international business environment are elaborated on. Further approaches how to overcome these difficulties are outlined by means of practical examples in a global working environment and in international teams. In addition, basic theoretical knowledge in communication and different models of communication are provided. Furthermore, it is defined how to deal with different communication styles of different cultures and how to communicate adequately in an international context. For this purpose, selected cultural characteristics and practical examples are used.

Within the framework of the course students are asked to reflect, analyse and evaluate already experienced situations in view of the discussed theoretical models. Additionally, ethically relevant problem areas in international/intercultural businesses are outlined.

Intended Learning Outcomes:
After attending this module students are able to apply basic scientific approaches to culture and cultural differences. On basis of appropriate knowledge about cultural theories, particular cultures, as well as general knowledge about the issues occurring when people with different cultural backgrounds interact the students are able to analyse cultural differences and difficulties in an intercultural business context, as well as to interpret and overcome them. Additionally, students are aware of different communication styles in different cultures and know to apply this knowledge in intercultural communication situations. Furthermore, students will bear integrity, ethics and responsibility in mind when making management decisions in a multicultural business environment. Students are also able to reflect their experience abroad with scientific intercultural knowledge and develop an open-mindedness and sensitivity with respect to cultural differences.

Teaching and Learning Methods:
The module is created as an online-course. It is divided in various thematic areas which contain basic theoretical knowledge. In addition, practical examples, case studies and videos illustrate relevant concepts and their application in an international (business-) environment. Further exercises are provided at the end of each thematic area in order to encourage students to tackle with specific intercultural subjects and to develop kind of intercultural sensitivity. Additionally, a bibliography is prepared for students' self-study. Practice questions for exam preparation are also offered.

Media:
Digital Scripts (PowerPoint Slides, PDF files), scientific literature and exercise questions

Reading List:
Standard references (amongst others):
Hall, Edward T.; Hall, Mildred Reed (1990): Understanding Cultural Differences. Maine: Intercultural Press.
Hill, C.W.L. and Hernández-Requejo, W. (2011): Global Business Today, Seventh edition
Hofstede, Geert (2001): Culture's Consequences. Comparing Values, Behaviors, Institutions, and Organizations Across Nations. 2nd edit. Thousand Oaks: SAGE Publications Inc.
Thomas, Alexander; Kinast, Eva-Ulrike; Schroll-Machl, Sylia (Hg.) (2010): Handbook of Intercultural Communication and Cooper. Basics and Areas of Application : Volume 1: Basics and Areas of Application. 2nd revised edition. Göttingen, Berlin: Vandenhoeck & Ruprecht GmbH & Co. KG
Trompenaars, Fons; Hampden-Turner, Charles (2012): Riding the waves of culture. Understanding diversity in global business. Revised and updated 3rd edition. New York: Mc Graw Hill.

Responsible for Module:
Moog, Martin; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced International Experience (WI001181) (lecture, 4 SWS)
Moog M [L], Heinze S, Moog M, Oesingmann K

For further information in this module, please click
campus.tum.de or here.

Double Degree Program HEC Paris

Technische Universität München

Module Description

WI700006: Modules from HEC Paris

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	Language taught		winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
60			

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
Within this module courses of the double degree program with Grand École des Hautes Études Commerciales (HEC) can be recognized. If you are interested in the program, you can find more information here: https://www.wi.tum.de/student-life/joint-international-programs/.

Repeat Examination:

(Recommended) Prerequisites:

Content:

Intended Learning Outcomes:

Teaching and Learning Methods:

Media:

Reading List:

Responsible for Module:

Courses (Type of course, Weekly hours per semester), Instructor:

Technische Universität München

For further information in this module, please click
campus.tum.de or here.

Master's Thesis

Technische Universität München

Module Description

WI900249: Master's Thesis (Master in Management and Technology)

TUM School of Management

Module Level:	Language:	Duration:	Frequency:
Master	German/English		winter/summer semester
Credits:*	**Total Hours:**	**Self-study Hours:**	**Contact Hours:**
30	900	900	

Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The Master's Thesis is the final paper on a specific topic in business administration or economics. The thesis usually requires six months of work. Students describe and analyze the state of research on a specific topic. Based on the scientific knowledge and methodical skills acquired during their studies, students autonomously find an answer to their research question, or provide a solution to a specific problem. The Master's Thesis is supervised by a professor of the TUM School of Management or a professor who teaches on the program Master Management & Technology.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Students can start their Thesis after the successful completion of at least 48 credits, of which at least 18 credits are from the technology specialization.

Content:
The Master's Thesis focuses on a research topic in business administration or economics, often with a special focus on engineering and natural sciences. The thesis is supervised by a professor of the TUM School of Management or a professor who teaches on the program Master Management & Technology, often in collaboration with a company or a research institution. The Thesis must be completed within six months.

Intended Learning Outcomes:
At the end of the module Master's Thesis, students are able to independently and systematically complete a scientific project. Therefore, students deploy their scientific knowledge and methodical skills to the specific subject. They describe the state-of-the-art knowledge in the specific field, conduct the research, evaluate the findings, and classify them within the scientific and or practical discussion. So, students are able to independently address new and complex research questions and also develop their own solutions and recommendations.

Teaching and Learning Methods:
The thesis should familiarize students with scientific work and should give them deep insights into a specific topic. Therefore, students apply their knowledge and methodical skills, acquired during the studies, and create a scientific manuscript within the set time frame.

Media:
literature, presentations

Reading List:
specific literature based on the topic

Responsible for Module:
Fuchs, Christoph; Prof. Dr.

Courses (Type of course, Weekly hours per semester), Instructor:

For further information in this module, please click
campus.tum.de or here.

Deferred conditions

Requirement Proof of Proficiency in German

Ingenieur-Naturwissenschaftliches Fach im Bachelor

Im Bachelor: Computer Engineering

-

Im Bachelor: Chemie

- -

Im Bachelor: Elektro- und Informationstechnik

- - -

Im Bachelor: Informatik

- - - -

Im Bachelor: Maschinenwesen

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