# Module Catalog

*M.Sc.*

TUM Campus Straubing for Biotechnology and Sustainability (TUMCS)
Technische Universität München

www.tum.de/
www.cs.tum.de/

# 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.

# Index of module handbook descriptions (SPO tree)

Alphabetical index can be found on page 696

# Fundamentals in Sustainable Management | Fundamentals in Sustainable Management

## Research Methods | Research Methods

## Module Description

## CS0096: Advanced Empirical Research Methods | Advanced Empirical Research Methods

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>120 | **Contact Hours:**<br>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 seminar paper with a maximum length of 15 pages. The students analyze a provided data set based on an individually posed question. The results are written down and submitted in the form of a seminar paper that has the structure of a scientific paper. The length of the seminar paper is a maximum of 15 pages. The students should be able to select, justify and implement suitable econometric methods for economic impact assessment based on the given question.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Statistics

**Content:**
Selected statistical methods required for impact analysis in the economics field, e.g. Difference in Difference, Propensity Score Matching, Instrumental Variable Method. Problems of endogeneity and selfselection bias during data collection and analysis. Conception of suitable data collections. The methods will be presented in the lecture. As part of the exercise, its application is carried out on concrete case studies

**Intended Learning Outcomes:**
After attending the module, students will be familiar with the most important statistical methods in the field of Impact Assessment to address the problem of endogeneity and the selfselection bias in economic and social sciences. They are able to select and execute the appropriate statistical models for specific case studies. They know how to collect data themselves in order to perform such impact assessment. In addition, students are able to understand statistics in scientific literature (peer reviewed journals).

**Teaching and Learning Methods:**
The lecture and exercise will be done using Powerpoint and Stata. In addition, scientifically published studies will be integrated into the lectures. In the exercise, the students themselves analyze data sets that are made available. The results of the case studies are then discussed and questioned individually and / or in groups from different perspectives by the students. Scientific publications using statistical analysis are analyzed and discussed by the students.

**Media:**
Presentations, slide scripts, Articles

**Reading List:**
Kleiber & Zeileis (2008): Applied Econometrics with R, Springer; Angrist & Pischke (2009): Mostly Harmless Econometrics: An Empiricist's Companion, Princeton Univers. Press.

**Responsible for Module:**
Faße, Anja; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Empirical Research Methods (Lecture) (Vorlesung, 2 SWS)
Faße A [L], Faße A

Advanced Empirical Research Methods (Exercise) (Übung, 2 SWS)
Faße A [L], Richter S, Shayo G
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0120: Advanced Sustainability and Life Cycle Assessment | Advanced Sustainability and Life Cycle Assessment

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Written exam (90 minutes): Students have to solve problems from the thematic field of the module. They have to prove their ability to use the right vocabulary, apply their knowledge on advanced topics in life cycle and systems thinking, sustainability and and life cycle assessment. Learning aids: pocket calculator.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Fundamental knowledge in Life Cycle Assessment as demonstrated e.g. by the successful participation of the module Material Flow Analysis and Life Cycle Assessment or Principles of LCA.

**Content:**
The module contains units covering the following topics:
• Systems and life cycle thinking
• LCA following the ISO 14040/14044 and ILCD standards
• Extension of Life Cycle Assessment to Life Cycle Sustainability Assessments
• Advanced Life Cycle Impact Assessment Methods such as for
- Land use and land use change
- Water use
- Resource use
• Attributional and consequential assessments
• Regionalisation of inventories and impact assessments
• Hybrid approaches
• Uncertainty handling

• Interface with Multi Criteria Decision Analysis
• Presentation and visualisation of results
• Handling of data uncertainty
• Current trends and developments
• Software systems and data bases for material flow analysis and life cycle assessment
• Case studies

**Intended Learning Outcomes:**
The students use advanced concepts and tools of sustainability and life cycle assessment to assess products, services and processesregarding their environmental impacts. Thus, they are able to gain a deeper understanding of their underlying material and energy flows and how they impact the environment. With these competencies development and improvement of systems, products and services can be supported, decision support delivered and communication with stakeholders aided.

**Teaching and Learning Methods:**
Format: lecture and (computer-based) exercises to introduce the content, to repeat and deepen the understanding as well as practice individually and in groups.

Teaching / learning methods:
- Media-assisted presentations
- Group work / case studies with presentation
- Individual assignments and presentation
- Computer lab exercises using LCA software systems and Life Cycle Inventory Data bases.

**Media:**
Digital projector, board, flipchart, online contents, case studies, computer lab

**Reading List:**
Recommended reading:
• Curran, M.A. (2015): Life Cycle Assessment Student Handbook, Scrivener Publishing:
• Hauschild, M.Z. & Huijbregts, M.A.J. (2015): Life Cycle Impact Assessment (LCA Compendium - The Complete World of Life Cycle Assessment), Springer.
• Klöpffer, W. & Grahl, B. (2014): Life Cycle Assessment (LCA), Wiley-VCH.
• Recent articles from esp. International Journal of Life Cycle Assessment, Journal of Cleaner Production, Journal of Industrial Ecology, Environmental Science and Technology (to be announced in the lecture)

**Responsible for Module:**
Fröhling, Magnus; Prof. Dr. rer. pol.

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

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

# Module Description

## CS0098: Operations Research | Operations Research

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Assessment takes the form of a written examination. In that examination, students must demonstrate their ability to formulate and solve decision models with appropriate methods. Type of assessment: in writing  duration of assessment: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Bachelor Business administration; advanced knowledge of mathematics and statistics

**Content:**
The module is divided into six distinctive areas:

Part 1: Basic Concepts
Part 2: Quantitative Modelling
Part 3: Linear Optimization
Part 4: Graph Theorie
Part 5: Integer and Combinatorical Optimization
Part 6: Dynamic Optimization

**Intended Learning Outcomes:**
The course introduces fundamental and advanced methods for modeling and solution of business problems with concepts from Operations Research (OR). Students will be introduced to using quantitative methods for planning and decision-making in companies and societies. Students will apply analytical methods of problem-solving and decision-making that is useful in the management of organizations.

**Teaching and Learning Methods:**
Lecture (theory), tutorials with group work and presentation

**Media:**
Seminaristic tution using beamer, overhead projector, flipchart

**Reading List:**
Hilier, F. and Lieberman, G., Introduction to Operations Research, McGraw-Hill, 2009
Kallrath, J and Wilson, J. M., Business Optimisation using mathematical Programming, London (Macmillan) 1997
Winston, W.: Operations Research - Applications and Algorithms. 4th ed. (internat. student ed.), Belmont, Calif. (Duxbury), 2004.
Taha, H. A., Operations Research, 7th ed., Upper Saddle River, N.J. (Prentice Hall) 2003.
Domschke, W., Drexl, A., Klein, R., Scholl, A, Einführung in Operations Research, Berlin (Springer) 2015.
Domschke, W. et al., Übungen und Fallbeispiele zum Operations Research, Springer, Berlin–Heidelberg, 2015

**Responsible for Module:**
Hübner, Alexander; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Operations Research (Vorlesung mit integrierten Übungen, 4 SWS)
Hübner A [L], Hübner A, Riesenegger L
For further information in this module, please click campus.tum.de or here.

## Specialization in Management | Specialization in Management

## Module Description

## CS0060: Business Game in Sustainable Management | Business Game in Sustainable Management

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Because of the mediation of competences and the interactive character of the module using the supply chain  simulation „The Fresh Connection" several group presentations are part of the evaluation:
- Introductory presentation for a supply chain topic (30 minutes / 50% of the evaluation)
- Short presentation concerning decision alternatives within a round of the simulation (10 minutes / 20% of the evaluation)
- Presentations of the decisions made within the respective rounds of the simulation, the lessons learnt and the results (15 minutes / 30% of the evaluation)

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Supply Chain Planning

**Content:**
The module is an innovative combination of mediation of theoretical background knowledge, practice and experience using the supply chain simulation „The Fresh Connection". The topics in detail:
- Basics and decision making in supply chain management
- Supplier Management
- Demand Management
- Capacity and Production Management
- Inventory Management and Planning

- Supply Chain Mapping and component characteristics
- Supply Chain Strategy
- Variables and KPI‘s on strategic and tactical level
- External Collaboration

**Intended Learning Outcomes:**
The students will obtain a practice oriented overview of basics, decisions and interrelations in supply chain management. The students will achieve the ability to understand influencing factors and consequences of supply chain decisions with the help of the simulation “The Fresh Connection“. The students will achieve the competence for autonomous academic self study and application-oriented presentation of content. A focus of the mediation of competences is on work in cross-functional teams.

**Teaching and Learning Methods:**
Lecture, Web-based supply chain management simulation and learning environment, self study and group work with presentation of result

**Media:**
Lecture, simulation software, presentations

**Reading List:**
Fisher, M.L. , What is the right supply chain for your product?, Harvard Business Review, March-April 1997
Christopher, M. , Logistics and Supply Chain Management, creating value-added networks, Prentice Hall, 2005
Chopra, S. and Meindl, Supply Chain Management, Pearson Education, third edition, 2007

**Responsible for Module:**
Alexander Hübner alexander.huebner@tum.de

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

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

## Module Description

### CS0113: Innovation in Bioeconomy | Innovation in Bioeconomy

Version of module description: Gültig ab winterterm 2024/25

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>120 | **Contact Hours:**<br>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 written exam (90 Minutes). The written form of the exam allows a comprehensive assessment of students' knowledge and understanding of the principles of innovation management and entrepreneurship with a focus on bioeconomic questions and concepts. Building on a core understanding of the principles of innovation management and entrepreneurship, students will answer questions about the more recent innovation and entrepreneurship concepts and have the ability to explain the adapted strategies and options for new ventures firms. They will also be able to assess the relevance of technologies and resources related to the bioeconomy and the different options to design sustainable business models in the context of bioeconomic questions.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Entrepreneurship, Introduction to Innovation Management

**Content:**
The module introduces students into advanced principles of innovation management and entrepreneurship from a sustainable perspective. Students will be equiped with basic knowledge on:
- design of business models to implement sustainable innovation
- advanced methods to generate and implement sustainable innovation
- role of ecosystems and networks

Beyond that, students will engage in break-out group workshops to personally experience the process of developing and evaluating sustainable innovation activities. Students give presentations to the audience and discuss their results.

**Intended Learning Outcomes:**
Following the completion of the course, the students will be familiarized with theoretical concepts and empirical methods to:
• assess the different forms and contents for identifiying and organising entrepreneurial ideas and innovative solutions in the context of the Bioeconomy by including broader economic, environmental and societal effects
• derive recommendations about the design and practices of innovation management and entrepreneurship and how to implement sustainable innovation
• identify and evaluate environmental technologies and design scenarios for firms to implement sustainable innovation

**Teaching and Learning Methods:**
The module will combine several learning methods.
- The basic knowledge as well as real world examples and case studies will be provided through the lecture.
- Discussions in the lecture and active participation are encouraged and will contribute to deepen the understanding of the concepts introduced.
- In the tutorial, the academic concepts will be discussed and applied in case studies. The students will further apply (part of) their theoretical knowledge to real-world problems and present their results in teams. This format fosters team work.
- Students will get additional background knowledge from the scientific literature in private reading.

**Media:**
Presentation, Power-Point Slides, Case Studies

**Reading List:**
The reading list is compiled from the latest contributions of relevant scientific journals, including the Academy of Management Journal, Research Policy, Strategic Management Journal, and will be made available to the students.

**Responsible for Module:**
Doblinger, Claudia; Prof. Dr. rer. pol. habil.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Innovation in Bioeconomy (Lecture) (Vorlesung, 2 SWS)
Doblinger C [L], Doblinger C

Innovation in Bioeconomy (Exercise) (Übung, 2 SWS)
Doblinger C [L], Doblinger C, Fischer D
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0128: Corporate Sustainability Management | Corporate Sustainability Management [CSM]

Version of module description: Gültig ab summerterm 2023

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

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

**Description of Examination Method:**
Written exam (90 minutes): Students have to solve problems from the thematic field of the module. They have to prove their ability to use the right vocabulary, apply their knowledge on advanced topics in strategic and operational sustainability management.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
None

**Content:**
The Corporate Sustainability Management module includes a detailed discussion of the term sustainability (three-pillar model) and the history of the content. Based on this, the basic premises for sustainable management and sustainable economic activity are derived and discussed in a social, political, environmental, economic and corporate context. The national, European and international strategies for sustainable management are presented (e.g. bioeconomy, circular economy, green economy). Furthermore, established measurement concepts and key performance indicators (KPIs) for sustainability (e.g. resource productivity, life cycle costing) are discussed and applied to exemplary products and value chains within the framework of "Corporate Social Responsibility Reporting".

**Intended Learning Outcomes:**
After completion of the module, the students are able to understand sustainability concepts and to compare sustainability-oriented corporate profiles as a supplement to value-added corporate development. They can develop and apply concepts for the derivation, evaluation and operational integration of economic, ecological and social indicators. This enables the students to carry out

sustainability assessments based on common and innovative new measurement concepts and indicators and to apply the results in the company.

**Teaching and Learning Methods:**
The module includes a lecture and an exercise. During the lecture, the content is communicated by presentations and discussions. The lectures serves to communicate the theoretical basics and terms of sustainability management including small exercises for group work. The students are encouraged to further deepen their knowledge of the proposed literature. As the highest level of competence, the lecture communicates an understanding of the evaluation of various sustainability concepts for use in operational management.
In the exercise, the students deepen the knowledge they have acquired by case studies. The content of the lectures and exercises is deepened both in small working groups and in individual work. As the highest level of competence, the exercise conveys the step-by-step development and incorporation of sustainability concepts using case studies of real and fictitious company concepts to achieve strategic and operational targets for sustainable development of the selected company.

**Media:**
Presentations, slide scripts, case descriptions of real and fictitious companies with sustainability management problems

**Reading List:**
Müller-Christ, G. (2010) Sustainable Management. Introduction into Resource Orientation and Contradictory Management Rationalities. Baden-Baden: Nomos
Schellnhuber, H. J.; Molina, M.; Stern, N.; Huber, V.; Kadner, S. (2010): Global Sustainability. A Nobel Cause. New York: Cambridge University Press
Seliger, G. (2012): Sustainable Manufacturing. Shaping Global Value Creation. Berlin: Springer
Von Hauff, M.; Kleine, A. (2009): Nachhaltige Entwicklung (Sustainable Development). Grundlagen und Umsetzung (Basics and Implementation). München: Oldenburg Wissenschaftsverlag

**Responsible for Module:**
Röder, Hubert; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Corporate Sustainability Management (Exercise) (Übung, 3 SWS)
Röder H [L], Röder H

Corporate Sustainability Management (Lecture) (Vorlesung, 1 SWS)
Röder H [L], Röder H
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0169: Sustainable Supply Chain Management | Sustainable Supply Chain Management

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**

Exam: 50%
presentation: 50%

The combination of grading methods is necessary to evaluate the skills acquired in this course
- Written exam: 45 minutes written exam on presentation, recommended readings, and case studies
- Oral report/presentation: Preparation of an reports in tandem teams with presentation and discussion. The report can be provided as slide-based summary of the presentation. Objective is the preparation of and summary of a current research paper in the field of the lecture; the list of papers is provided at the beginning of the course; All parts have to be passed and cannot be retaken

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Bachelor Business administration; advanced knowledge of Mathematics, Statistics and Operations Research

**Content:**
The course covers decision-oriented aspects of SCM and discusses basic concepts, models, and methods for hierarchical planning in supply chains.This course content provides the foundation for a critical examination of planning systems from a theoretical and practical perspective. This builds the foundation to study case studies and papers with respect to sustainability.

**Intended Learning Outcomes:**
The students:
- know the conceptual structure of supply chain planning and understand basic concepts, models, and methods that are applied in supply chain management
- gain experience in the supply chain management using prevalent software systems and understand scope and limitations in supporting practical decision situations.
- hone their skills with respect to modeling and solving decision problems in sustainable supply chain management.

**Teaching and Learning Methods:**
Lecture (theory), tutorials with group work and presentation

**Media:**
Seminaristic tution using beamer, overhead projector, flipchart

**Reading List:**
Stadtler/Kilger/Meyr (2015): Supply Chain Management and Advanced Planning. Concepts, Models, Software, and Case Studies. 4. Aufl., Springer (Berlin).
Cachon/Terwiesch (2012): Matching Supply with Demand
Chopra/Meindl (2009): Supply Chain Management: Strategy, Planning, and Operation, Global Edition

**Responsible for Module:**
Alexander Hübner alexander.huebner@tum.de

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

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

# Module Description

## CS0121: Sustainable Production | Sustainable Production [SP]

Version of module description: Gültig ab winterterm 2020/21

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

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

**Description of Examination Method:**
Written exam (90 minutes): By solving problems from the thematic field of the module students have to prove their understanding of the management of industrial production processes and technologies under consideration of sustainability aspects. In doing so they have to prove their techno-economic understanding, knowledge on quantitative methods for the analysis, assessment and optimisation of production systems, as well as their analytical and verbal skills in the field. They need to show that they are able to discuss the treated approaches and to derive further research needs. Learning aids: pocket calculator.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
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**Content:**
The module covers inter alia the following topics:
• Sustainability aspects of industrial production and consumption
• Reasons for considering sustainability aspects in production management
• Measuring sustainability of production and operations
• Sustainable product and service design
• Sustainable sourcing
• Sustainable production management
• Sustainability of logistics
• Managing wastes, waste water, air emissions and product returns

**Intended Learning Outcomes:**
The module aims at enabling students to approach management tasks of production systems under consideration of sustainability aspects. This covers especially , especially the analysis, assessment and optimisation of these using a quantitative systems analysis approach.

The students understand that production and consumption activities have sustainability impacts and why these have to be considered in the management of production systems. They apply quantitative approaches for the analysis, assessment and optimisation of these systems on example planning tasks. They are capable to discuss the approaches critically, derive further development needs and transfer these approaches to other fields.

**Teaching and Learning Methods:**
Format: Lecture with exercise to introduce, train and deepen the contents of the module.

Teaching / learning methods:
- Media-assisted presentations
- Group work / case studies with presentation
- Individulal assignments and presentation

The teaching and learning methods are combinded specifically for the treated topics. Typically, a thematic impulse or overview is given with a media-assisted presentation. Individual or group work assignments provide the possibility to apply the acquired competencies, to repeat and deepen these as well as to prepare the transfer to other fields.

**Media:**
Digital projector, board, flipchart, online contents, case studies

**Reading List:**
Recommended reading:
• Stark R; Seliger G, Bonvoisin J (2017): Sustainable Manufacturing - Challenges, Solutions and Implementation Perspectives , Springer
• Reniers G, Sörensen K, Vranken K (2013): Management principles of sustainable industrial chemistry, Wiley VCH
• McKinnon A, Browne M, Piecyk M, Whiteing A (2015): Green Logistics, Kogan Page
• Mangla S, Luthra S, Jakhar S K, Kumar A, Rana N P (2019): Sustainable Procurement in Supply Chain Operations, CRC Press

Further related reading, especially articles in international peer reviewed journals, will be provided in the kick-off meeting of the module.

**Responsible for Module:**
Fröhling, Magnus; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Sustainable Production (Vorlesung) (Vorlesung, 2 SWS)
Fröhling M [L], Heinrich V, Schirmeister J

Sustainable Production (Übung) (Übung, 2 SWS)
Fröhling M [L], Schirmeister J, Heinrich V
For further information in this module, please click campus.tum.de or here.

## Module Description

### CS0174: Marketing for Biobased Products | Marketing for Biobased Products [MBBP]

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
The exam will be in form of an oral exam. By answering questions students have to show that they have understood and can apply the thaught specific principles of the marketing of bio-based products and industrial marketing. No additional tools are allowed during oral examination with a duration of 15 minutes. In a students' project, the students demonstrate the scientific analysis and possible solutions of specific questions related to a defined topic concerning the marketing of biobased products including industrial marketing. The results of the project work will be presented (20 min; passed/non-passed) by the students with subsequent discussion with the other students and the lecturers.
In this students' project, the students demonstrate understanding of specific questions related to a defined topic concerning the marketing of bio-based products and services. Students have to show in their presentation that they can analyse, solve and answer defined problems and questions related to this topic. Participants of the course show that they have done appropriate research work and are able to present their results. By answering follow-up questions related to their presentation they show that they have learned to put their research outcome into the relevant product and market context.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basic know-how related to marketing and markets of biobased products is recommended

**Content:**
The content of the module comprises in one part specific aspects of the marketing of biobased products and services. This part includes in particular the modification of methods and instruments of strategic marketing to this specific group of products and services (e.g. holistic character

of change in raw material basis, use of by-products and cycle approaches), the particular target groups of such products and their behavior (e.g. characteristics of related target groups, attitude-behaviour gaps), adaptations in the marketing-mix (e.g. specific benefits, labelling and identification of biobased products, avoidance of greenwashing, biomass logistics) as well as specific aspects related to the marketing of sustainability-oriented products and services (e.g. sustainable consumption and its barriers, sustainability evaluation and standards, Fair trade).
Industrial marketing will be thaught in a second part of the module with a focus on specific tasks of industrial marketing, characteristics of different transaction types, specific features of transactions and service offers in the business-to-business area, as well as the combination of value chains, customer integration and service offers. Additionally, the procurement of business and state organisations will be considered with a focus on uncertainty and information as important factors in the buying process as well as concepts to analysing a buying center.
Besides, the students will use the taught methods and tools in a students' project in which actual questions and case studies related to the marketing of biobased products and services under consideration of industrial marketing will be analysed and answered.

**Intended Learning Outcomes:**
After attending the module, students will be able to use the instruments and methods of strategic and operational marketing related to biobased products and services thereby considering the specific aspects of industrial marketing in this context. They can deflect specific target groups for biobased products and services, analyse their behavior and derive targeted marketing strategies and their operationalization. Additionally, students can analyse the specific characteristics and challenges of sustainability-oriented products and services and are able to assess these in form of adapted marketing strategies and concepts. Students can evaluate the principles and specific tools of industrial marketing and can use these in the field of biobased products and services.
Besides, students can distinguish important theoretical and practical approaches related to the procurement of business or state organisations and rate those with the specific characteristics of biobased products and services.

**Teaching and Learning Methods:**
The lecture will be done using Powerpoint with specifically worked out presentation scripts. In addition, published studies, scientific papers and statistical data will be integrated into the lectures.
In the students' project, students use the taught methods and instruments of the marketing of biobased products and services, industrial marketing as well as their factual knowledge to analyse actual questions and cast studies related to the application fields of biobased products and services and derive adapted marketing strategies and concepts. They will present and discuss their approach and solutions with their colleagues and the lecturers.

**Media:**
Presentation slides, actual literature and studies, online discussion forum (all lecture materials are available via Moodle)

**Reading List:**
Specific literature and documents will be provided to the topics of the lectures as well as the topics that are worked on in the student projects

**Responsible for Module:**
Menrad, Klaus; Prof. Dr.sc.agr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Specific aspects of the marketing of biobased products (Vorlesung, 1 SWS)
Menrad K [L], Menrad K

Applied marketing for biobased products (Projekt, 2 SWS)
Menrad K [L], Menrad K, Stelzl B

Industrial marketing (Vorlesung, 1 SWS)
Menrad K [L], Stelzl B
For further information in this module, please click campus.tum.de or here.

## Major | Major

## Biotechnology and Material Science | Biotechnology and Material Science

## Specialization in Engineering and Natural Sciences | Specialization in Engineering and Natural Sciences

## Module Description

## CS0102: Introduction to Game Theory | Introduction to Game Theory [IGT]

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
Learning outcomes are verified in a written exam (90 minutes). Students show the extent to which they have understood the taught game-theoretical definitions and terminology. They show to which extend they are able to use games in order to model problems from economics and engineering. They are also expected to apply important solution concepts to concrete games and answer comprehension questions concerning the properties and the advantages and disadvantages of the different solution concepts.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Module Mathematics (WZ1601) or Advanced Mathematics 1 (CS0175)

**Content:**
Cooperative and non-cooperative games, solution concepts for cooperative games, core, Shapley value, solution concepts for non-cooperative games, pure Nash equilibria, mixed Nash equilibria, dominant strategies, Bayesian games, modeling concrete case studies related to sustainability as cooperative and non-cooperative games

**Intended Learning Outcomes:**
Students have aquired basic theoretical and practical knowledge on cooperative and non-cooperative games. They know the basic definitions and terminology and are able to model sustainability-related problems from economics and engineering as games. Students know the most important solution concepts for cooperative games (such as the core and the Shapley value) and non-cooperative games (such as Nash equilibria and dominant strategies). They have gained a good understanding of these concepts and are able to analyze concrete games by using them.

**Teaching and Learning Methods:**
Lectures introduce basic knowledge; tutorials practice modelling of application problems as games and applying solution concepts to concrete examples.

**Media:**
Lectures given as presentations (projector and/oder blackboard), tutorials with group work and exercise sheets

**Reading List:**
Manfred J. Holler, Gerhard Illing, Stefan Napel - Einführung in die Spieltheorie, 8. Auflage, Springer Gabler, 2019.
Steven Tadelis - Game Theory: An Introduction, Princeton University Press, 2013.
M. J. Osborne and A. Rubinstein - A Course in Game Theory, MIT Press, 1994

**Responsible for Module:**
Thielen, Clemens; 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

## WZ1193: Biogas Technology | Biogastechnologie [BiGA]

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>100 | **Contact Hours:**<br>50 |

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

**Description of Examination Method:**
Students take a written examination (90 minutes) to demonstrate their knowledge of microbial breakdown processes in the biogas process, as well as their ability to assess influencing factors. They also demonstrate their knowledge of various technologies for using biogas and can explain their respective advantages and disadvantages. Additionally, they demonstrate that they have understood the legal and economic framework conditions of biogas technology and are able to translate these to case examples. Students also show that they can develop basic concepts of biogas plants.They will answer questions on the topic in their own wording and explain case examples or work out calculations. Multiple-choice questions are also possible.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Required: basic knowledge in biology, especially microbiology, as well as general and organic chemistry, mathematics, physics and thermodynamics of cycles; of advantage: knowledge in agriculture and agricultural engineering

**Content:**
Microbiology of biogas processing, anaerobic substrate breakdown, factors influencing the fermentation process, process management strategies, biogas storage and purification; biogas recovery (e.g. use of a motor for power generation with or without the use of heat or feeding into the gas grid); legal-economic framework conditions; sustainability issues; competition for raw material and acceptance of biogas plants; aspects of biogas plant design.

**Intended Learning Outcomes:**
After successful completion of the module, students are able to develop concepts for biogas generation and recovery in a specific context. Students are aware of microbial breakdown

processes in biogas plants and can differentiate between various influencing factors. They are also aware of various processes for the use of biogas and understand their advantages and disadvantages. Students recognize the meaning of biogas technology for sustainable energy supply. Students have a good knowledge of legal and economic framework conditions in the field of biogas generation and they are able to conceptualize basic biogas plants.

**Teaching and Learning Methods:**
Lectures given as presentations, with the help of a blackboard and interactive elements, in particular group work on case examples; optional: excursion to a biogas plant to deepen acquired knowledge in a real-life setting

**Media:**
PowerPoint presentation, slide notes, exercise sheets

**Reading List:**
D. Deublein, A. Steinhauser, Biogas from Waste and Renewable Resources - An Introduction, Wiley-VCH, 2010, ISBN-13: 978-3-527-32798-0, ISBN-10: 3-527-32798-3

**Responsible for Module:**
Doris Schieder (doris.schieder@tum.de)

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

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

# Module Description

## CS0100: Microbial and Plant Biotechnology | Microbial and Plant Biotechnology [MPBioTech]

Version of module description: Gültig ab summerterm 2023

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

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

**Description of Examination Method:**
In order to check whether students have understood and are able to apply the principles and relevant methods and techniques of biotechnological production processes, the students answer questions about production processes and fermentation strategies, as well as on important methods and applications in plant biotechnology in a written exam (90 min) and prove that they have understood the correlations of metabolism. Allowed tools are calculators.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Fundamentals of Biology or of cell and microbiology from the Bachelor's courses

**Content:**
In the lecture microbial biotechnology relevant topics and techniques of microbial biotechnology are presented. This includes the quantitative description of the metabolic performance of microorganisms, industrially relevant substrate sources, metabolic engineering strategies as well as examples of industrial production processes (e.g.: alcohols, amino and organic acids).
In the lecture plant biotechnology the most important model and crop plants in biotechnology are presented, classified and their morphological and physiological properties are emphasized. Major questions, methods and solutions will be discussed with thier pros and cons. Some of the topics to be discussed: legal framework, major appilcation of current plant genetic engineering, the Arabidopsis model system, snovel concepts for yield and quality improvement. One focus is on the challenges for agriculture caused by climate change and sustainable solutions.

**Intended Learning Outcomes:**
Upon successful completion of the module, students will be familiar with the principles and techniques of relevant microbial bioprocesses. The students have acquired knowledge of fermentation processes and are able to develop strategies for process control for selected product classes. The students have learned to quantitatively describe microbial growth and fermentation processes. The students have acquired in-depth knowledge of relevant production processes for selected products of industrial biotechnology and understand their importance for the development of sustainable chemistry. Also, the students know the most important methods and applications in plant biotechnology and are able to assess them.

**Teaching and Learning Methods:**
The contents of the lectures are conveyed by a talk of the lecturer, based on PowerPoint presentations. The blackboard might additionally be used to explain more complex relationships. To a limited extent, this can be supplemented by self-study of the literature mentioned in the lecture.

**Media:**
PowerPoint, whiteboard

**Reading List:**
Microbiology – an evolving science, J. L. Slonczewski, J. W. Foster, W W Norton & Co Inc, 4th edition, ISBN: 978-0-393-61403-9 (available in the library)
Molecular Biology of the Gene, I. D. Watson, T. A. Baker, A. Gann, M. Levine,
Losick, Pearson, 7th edition, ISBN-13: 978-0321762436 (available in the library)
Biotechnology, R. D. Schmid, C. Schmidt-Dannert, Wiley-VCH, 1st edition,
ISBN: 978-3-527-33515-2 (available in the library, eBook)
Industrial Microbiology, D. B. Wilson, H. Sahm, K.-P. Stahmann, M. Koffas,
Wiley-VCH, 1st edition, ISBN: 978-3-527-34035-4 (available in the library)
Industrial Biotechnology – Products and Processes, C. Wittmann, J. Liao,
Wiley-VCH, volume 4, ISBN: 978-3-527-34181-8 (available in the library, eBook)
Industrial Biotechnology – Microorganisms, C. Wittmann, J. Liao,
Wiley-VCH, volume 4, ISBN: 978-3-527-34179-5 (available in the library, eBook)
Campbell Biology N. A. Campbell, L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky, J. B. Reece, Pearson, 11th edition (2018)  (available in the library)

**Responsible for Module:**
Blombach, Bastian; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Microbial Biotechnology (Vorlesung, 2 SWS)
Blombach B [L], Blombach B

Applied Microbiology and Metabolic Engineering (Lecture) (Vorlesung, 2 SWS)
Blombach B [L], Blombach B, Glawischnig E

Plant Biotechnology (Lecture) (Vorlesung, 2 SWS)
Glawischnig E [L], Glawischnig E
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0012: Artificial Intelligence for Biotechnology | Artificial Intelligence for Biotechnology [AI]

Version of module description: Gültig ab summerterm 2024

| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
|---|---|---|---|
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The module examination takes the form of a presentation  followed by discussion. The learning outcomes are verified by a group project (3-4 students per group). The presentation of the developed code and the results of the project will be done together as a group, with each group member presenting one part. The presentation should be equally divided among the group members. After the presentation, each group member is asked individual questions about the project. The final grade will be based on the presentation and results of the project (duration of presentation and questions: approx. 30 min depending on group size; approx. 8-10  minutes per student).  As a voluntary mid-term effort, the students can take part in a multiple-choice test (duration: 10 minutes). If they achieve at least 65% of the points in this test, a bonus of 0.3 will be credited on the grade of the presantation (however, an improvement of the grade from 4.3 to 4.0 is not possible).

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Mathematical Skills in Linear Algebra and Statistics as well as Programming Skills in Python are expected

**Content:**
Technologies that generate analyses or predictions based on data can be found in almost all areas of our daily life (e.g. recommender systems, autonomous driving, and credit card fraud detection). These methods are also important for analyzing biological and biomedical data, e.g. for finding novel patterns in biological data, predicting the disease state of a patient, or the 3D structure of proteins. In this course, we will learn the fundamentals of machine learning and will apply these methods to various real-world problems.

The following contents will be treated exemplarily:
- Similarity and Distance Metrics
- Data Preprocessing and Visualization
- Dimensionality Reduction (e.g., Principal Component Analysis)
- Classification (Nearest-Neighbor, Logistic Regression, Decision Trees, Support Vector Machines (SVM))
- Model Selection and Hyperparameter Optimization (Confusion Matrix and Evaluation Measures, Cross-Validation, Hyperparameter tuning techniques, Common problems such as Over- vs. Underfitting)
- Clustering (K-Means, Hierarchical Clustering)
- Regression Models (Linear Regression, Support Vector Regression)

AI-based technologies have the potential to support many areas of biotechnology and sustainability, e.g. by guiding downstream research with data-driven predictions or supporting decision-making with demand forecasts. In this course, we will look at suitable practical examples and demonstrate their potential.

**Intended Learning Outcomes:**
The students know the fundamental and most important artificial intelligence, especially machine learning, methods and are able to apply them independently on various real-world problems. The students learn the basics of the programming language Python (one of the leading programming languages in the field of machine learning) and are able to implement and apply machine learning algorithms in Python. In addition, students are able to visualize and interpret different types of data and results independently. Students will understand how artificial intelligence can support areas of biotechnology and sustainability and are able to assess the potential of AI-based approaches in sustainability projects.

**Teaching and Learning Methods:**
Lectures to provide the students with all necessary fundamentals of artificial intelligence, especially of machine learning which they will need to independently apply these concepts to real-world data. In the exercises the students are introduced to the programming language Python, as well as to apply and implement these algorithms for specific case studies.

**Media:**
The lecture shall mainly be done by using PowerPoint presentations. During the exercise the students work at PCs to gain confidence in using the programming language Python. Students implement various machine learning methods in Python (e.g. using Jupyter Notebooks) and apply them on various examples. Students work on real world problems to implement learnt skills and to gain confidence in applying these different methods independently.

**Reading List:**
Murphy, K. P. (2012). Machine learning: a probabilistic perspective. MIT press.
Bishop, C. M. (2006). Pattern recognition and machine learning. Springer.
Raschka, S. (2017). Machine Learning mit Python. mitp Verlag.

Friedman, J., Hastie, T., & Tibshirani, R. (2001). The elements of statistical. Springer.

**Responsible for Module:**
Grimm, Dominik; 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

## CS0105: Modelling and Optimization of Energy Systems | Modelling and Optimization of Energy Systems [MOES]

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Assessment is done in a written examination (90 minutes). Participants of the course solve programming tasks to demonstrate that they are able to apply the methods aquired in the course. By answering questions related to case examples they show that they have learned to put things into their proper context.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Bachelor modules Mathematics, Physics, Numerical Methods;
Basic knowledge in Energy technology; basic programming experience (ideally with Matlab)

**Content:**
Basics of Modelling and Simulation:
- physical models
- data-based models (look-up tables, polynomials, neural networks)
- methods for generating models
Fundamental optimization methods:
- linear optimization (linear regression)
- nonlinear optimization

**Intended Learning Outcomes:**
After attending the course the participants understand basic methods for creating models, simulation and optimization. In addition, they are able to apply these methods by creating appropriate program code in Matlab. Furthermore, the participants acquire Matlab programming experience.

**Teaching and Learning Methods:**
The module consists of a lecture and an excercise. Lectures include presentations whose content is deepened by solving excercise problems autonomously. In order to improve the learning outcome, participants work at homework excercise problems. These are discussed in the next lecture.

**Media:**
PP presentation, whiteboard, demonstration of programs

**Reading List:**
S. R. Otto & J.P. Denier, An Introduction to Programming and Numerical Methods in MATLAB, Springer, London, 2005
O. Nelles, Nonlinear System Identification, Springer, Berlin, 2010

**Responsible for Module:**
Kainz, Josef; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Modelling and Optimization of Energy Systems (Vorlesung mit integrierten Übungen, 4 SWS)
Kainz J [L], Kainz J
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0101: Renewables Utilization | Renewables Utilization

Version of module description: Gültig ab winterterm 2020/21

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Assessment takes a written examination (90 minutes), with students to unterstand and to apply structure, transformation and use of different renewable resources. Students are required to answer questions using individual formulations and outline structures and reactions. In addition, sample calculations are to be worked out.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic lectures in chemistry; Basics on renewables utilization

**Content:**
Various types of ingredients of renewable raw materials: sugars, polysaccharides, fats and oils, amino acids, proteins, terpenes, aromatics. The following topics will be dealt with in more detail: structure, composition, occurrence, properties, analysis and type of added value or use in various examples.

**Intended Learning Outcomes:**
After completion of the modules, students understand the chemical composition of renewable resources as well as their production and application. Using this knowledge students are able to explain the respective advantages and disadvantages as well as analyze the underlying physical, chemical and biotechnological principles of their conversion into valuable products.

**Teaching and Learning Methods:**
Lecture and accompanying tutorial including individual work on specific examples.

**Media:**
Presentation, script, examples and solutions

**Reading List:**

**Responsible for Module:**
Rühmann, Broder; Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Renewables Utilization (Exercise) (Übung, 2 SWS)
Rühmann B

Renewables Utilization (Lecture) (Vorlesung, 2 SWS)
Sieber V [L], Rühmann B, Sieber V
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0009: Enzymatic Biotransformations | Enzymatic Biotransformations [IBT]

Version of module description: Gültig ab winterterm 2023/24

| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
|---|---|---|---|
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
The students should be able to understand and describe possibilities and limitations of established industrial enzymatic processes. This understanding and its application to derive ways to improve existing processes, making them more sustainable and to establish new ones, a written examination takes place with a duration of 90 minutes (approved tool: calculator). As a voluntary mid-term effort, the students can take part in three online test within the Moodle course of the exercise. If they achieve at least 65% of the points in these tests, a bonus of 0.3 will be credited on the grade of the written examination (however, an improvement of the grade from 4.3 to 4.0 is not possible).

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
The lecture provides a broad overview about applications of enzymes in industrial processes and detailed insight into the corresponding technically important aspects by means of current examples. Essential contents are: industrially relevant properties of enzymes, essential enzyme classes and the most important enzymatic mechanisms, whole cell catalysis vs. enzyme catalysis, biocatalysis vs. classical chemical catalysis, methods of enzyme immobilization, enzymes in aqueous and non-aqueous systems, enzymatic reactions combined with chemical reactions, large-scale supply of enzymes. On the application side, biotransformations which are necessary for the conversion of biogenic ressources are treated as well as reactions for the synthesis of bulk chemicals, fine chemicals and food additives.

**Intended Learning Outcomes:**
After participating in the lecture the students will be able to review possible applications of enzymes in different chemical and technical processes, to understand the behaviour and limitation of enzymes in these processes and to derive ways to establish new reactions biocatalytically and to propose technically meaningful scenarios for newly developed enzymatic processes respectively.

**Teaching and Learning Methods:**
The lecture will be performed as ex-cathedra teaching which is interrupted by queries to familiarize students with all necessary basics and to stimulate independent, critical thinking. In the exercise, the students will deepen the knowledge they have learned and solve specific problems of varying complexity, either alone or in group work.

**Media:**
PowerPoint, white board, exercise sheets or online questions

**Reading List:**

**Responsible for Module:**
Sieber, Volker; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Enzymatic Biotransformations (Exercise) (Übung, 1 SWS)
Sieber V [L], Arana Pena S, Hupfeld E

Enzymatic Biotransformations (Lecture) (Vorlesung, 2 SWS)
Sieber V [L], Sieber V
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0086: Wood-based Resources | Wood-based Resources

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Exam achievement shall be done in the form of a test. Product pathways of forestry and forest industry shall be reflected here. Classification of economic and ecological aspects of forestry and forest industry from cultivation to material and energetic use shall be explained by using examples of particular cases. Recognition of wood and wood materials shall be shown. The relation of knowledge of forestry and forest industry with regard to knowledge of different woods and wood utilisation will be evaluated at a ratio of 1 to 1. The answers require own formulations from the respective technical jargon of forestry and forest industry.
Type of exam: In writing. Exam duration: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**

**Content:**
The module aims at providing in-depth knowledge to the students in the field of forestry and forest industry from harvest to the use of wood. Special emphasis is given to the interfaces concerning wood use (sawing, wood materials and paper industry) and energy wood production. In a further aspect differences of woods shall be addressed from a microscopic point of view through to their field of application in the manufacturing industry. Therefore, students learn to classify woods microscopically and macroscopically.

**Intended Learning Outcomes:**
After attending the module the student shall be able to characterise the product pathways in forestry from crop establishment through to material and energetic use of wood. He distinguishes different forms of economy and is able to classify them according to economic, social and

ecological aspects. He recognises differences of woods, knows various new products produced from wood and understands their production paths and their markets.

**Teaching and Learning Methods:**
The course attendance of forestry and wood consists of a lecture and exercises. For this purpose powerpoint presentations amd practical training material shall be used. A study trip to wood processing plants including lectures from qualified personnel providing information
from experience on site with common rounds of questions provides in-depth knowledge of the production paths. A socalled wood block determination, i. e. the determination of wood by means of different genuine wood samples, will be performed by a magnifying glass 10x.

**Media:**
The following forms of media apply: Script, powerpoint, films, for determination exercises also branches and leaves of shrubs to be determined. Study trip to companies with guided tour of processing and treatment of wood. Determination of wood with a magnifying glass 10x.

**Reading List:**
D. Fengel and G. Wegener: Wood. Publisher: De Gruyter, https://doi.org/10.1515/9783110839654
Jörg van der Heide, 2011: Der Forstwirt. (The Forester) Publisher: Ulmer (Eugen); Auflage: 5th edition. (September
26, 2011)
Language: German
ISBN-10: 3800155702
ISBN-13: 978-3800155705; D. Fengel, G. Wegener: Wood Verlag Kessel, www.forstbuch.de

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Wood-based Resources (Exercise) (Übung, 2 SWS)
Zollfrank C [L], Röder H, Zollfrank C

Wood-based Resources (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Röder H, Zollfrank C
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0026: Advanced Concepts of Bioinformatics | Advanced Concepts of Bioinformatics

Version of module description: Gültig ab winterterm 2023/24

| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
|---|---|---|---|
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Learning outcomes shall be verified in a written test. Tasks shall be specified by means of which the students are to demonstrate that they know the bioinformatic methods imparted as part of the module and that they have understood and are able to apply them for specific case studies. Exam duration: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Module Biochemistry, WZ1631 Bioinformatics, CS0001 Foundations of Computer Science, Knowledge Linux Command Line Interface, Programming Skills in Python

**Content:**
In this course state-of-the-art methods in statistical genetics, genome-wide association studies, analysis of complex biological networks, protein-analysis as well as modern machine learning methods for genomic data are investigated and applied on various case-studies.

**Intended Learning Outcomes:**
The students know state-of-the-art bioinformatics methods and are able to apply them independently on various real-world problems. The students lern to implement custom Python scripts to analyse, visualise and interprete the results of these methods independently.

**Teaching and Learning Methods:**
Lectures to provide the students with the theoretical and practical concepts of state-of-the-art bioinformatics methods, which they will need to independently apply these methods on real-

world data. In the exercises the students will apply these tools on concrete case studies and will implement custom Python scripts to analyze, visualize and interpret the results.

**Media:**
The lecture shall mainly be done by using PowerPoint presentations. During the exercise the students work at PCs to gain confidence in using the bioinformatics tools. Students implement various custom Python scripts (e.g. using Jupyter Notebooks) to analyze, visualize and interpret the results of these tools. Students work on real world problems to implement learnt skills and to gain confidence in applying these different methods independently.

**Reading List:**
Pevsner, J. (2017). Bioinformatics and functional genomics. Wiley Blackwell.

**Responsible for Module:**
Dominik Grimm

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

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

# Module Description

## CS0134: Conceptual Process Design | Conceptual Process Design

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
The exam performance is effected by an oral exam. It is reviewed whether the students know the fundamentals of conceptual design of chemical and biotechnological processes and if they can apply this knowledge on the design and evaluation of complex processes. The exam consists of two parts: (a) 30 minutes preparation through solving a given problem set (b) 30 minutes of oral examination. In the beginning of part (b) the results of part (a) are presented by the student. (total duration 60 min)

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Knowleadge of thermodynamics and apparatusses used for fluid sparations processes. It is recommended to visit at least the course "Introduction of Process Engineering" first.

**Content:**
Basics of cenceptual design of processes; Basics of computational process design including calculation of process parameters; transfer of fundamental scale-up criteria towards real problem solving; Balancing of all process streams; Deepened knowledge of engineering principles.

**Intended Learning Outcomes:**
The students are qualified to understand the fundamentals of design, calculations, and balancing of chemical processes and fluid separation courses after the course. They will aquire knowledge of different challenges of process design and how to master them.

**Teaching and Learning Methods:**
The module consists of lectures and parallel tutorials. Contents of the lecture shall be imparted in speech and by presentation. In the exercises performed as part of the module learned theory

shall directly be applied with a practical orientation by means of calculations and examples from targeted aspects of process design and calculation. based on a direct comparison of a chemical process with it´s biotechnical alternative they learn to apply their knowledge on reality based challenges. Additionally they will be qualified by an in-depth knowledge of the design of operation units including calculation of process parameters based on utilization of selected software tools.

**Media:**
Panel, slides, scripts, practical exercises

**Reading List:**
Moulijn et al. (2013). Chemical Process Technology. – John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, United Kingdom.
# Biegler et al. (1997). Systematic Methods of Chemical Process Design. – Prentice Hall.
# Doherty, M.F., Malone, M.F. (2001). Conceptual design of distillation systems. – Boston: McGraw-Hill.
# Gmehling, J., Kolbe, B., Kleiber, M., Rarey, J. (2012). Chemical Thermodynamics for Process Simulation. 1. Auflage. Weinheim: Wiley – VCH
# Grassmann, P., Widmer, F., Sinn, H. (1997). Einführung in die Thermische Verfahrenstechnik. 3. vollst. überarb. Auflage. Berlin: de Gruyter.
# Stichlmair, J.G., Fair, J.R. (1998). Distillation: Principles and Practice. – New York: Wiley – VCH.

**Responsible for Module:**
Burger, Jakob; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Conceptual Process Design (Lecture) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Ibanez M, Staudt J

Conceptual Process Design (Exercise) (Übung, 2 SWS)
Burger J, Rosen N, Wolf A
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0170: Advanced Modelling and Optimization | Advanced Modelling and Optimization

Version of module description: Gültig ab winterterm 2021/22

| **Module Level:** Master | **Language:** German/English | **Duration:** one semester | **Frequency:** summer semester |
|---|---|---|---|
| **Credits:*** 7 | **Total Hours:** 210 | **Self-study Hours:** 150 | **Contact Hours:** 60 |

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

**Description of Examination Method:**
The examination is based on two project works (each 50% of evaluation).

The project works examine the understanding of the modeling and programming techniques discussed in the course. The project works includes, appling algorithms to solve problems, creating mathematical models for examplary problems, and discuss presented results. By this the students have to demonstrate that they have understood and can apply the mathematical models and methods to solve planning problems. The project paper serves the assessment of the understanding of the modeling and programming language.

For the project paper the participants get a randomly assigned fictive, extensive decision problem. For this problem, the following has to be prepared:
- a modeling of the problem as a mathematical program, as well as explanation of the program
- an implementation of the program in a known optimization and programming language
- a verbal and graphical explanation of the of the results for the original problem

The grading of the project paper is done by the following criteria:
- Correctness of modeling and implementation as well as of the results (60% of examination)
- Clarity, comprehensibility and efficiency of the implementation (30% of evaluation)
- correct language, typesetting and outer form of the paper (10% of evaluation)

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Operations Research (CS0098)

**Content:**
This course is about modeling, solving and analyzing planning and decision problems using mathematial concepts. The course teaches the basics of linear, discrete and dynamic optimization. In addition, there is an introduction to optimization and corresponding programming languages, as well as teaching methods for analyzing and structuring algorithms, designing suitable object-oriented data structures, applying known standard algorithms and connecting them to other resources and programming environments.

**Intended Learning Outcomes:**
After successful completion of the module students are capable of modelling planning problems. Students learn to model real life business problems by applying mathematical programming techniques. They can independently implement mathematical models by using an optimization language and heuristical approaches. They are able to solve the models within the scope of a case study and can interpret the results. Furthermore, they deepen their knowledge in several different modeling techniques and basics of object oriented programming.

**Teaching and Learning Methods:**
The module consists of a lecture and exercise courses, which are provided weekly. In the lecture the content is jointly developed with the students mainly by using slides. The exercise course repeats parts of the lecture contents by using examples and offering the opportunitis to implement poblems individually. The excercises give the student the opportunity to pose questions and receive immediately help from the teaching assistant.

**Media:**
Script, Presentation slides

**Reading List:**
Hilier, F. and Lieberman, G., Introduction to Operations Research, McGraw-Hill, 2009
Popp, Andreas: Modellierung und Optimierung mit OPL. epubli, 2015
Schildt, H.: Java, A Beginner's Guide, 5th Edition, McGraw-hill, 2011
Winston, W.: Operations Research - Applications and Algorithms. 4th ed. (internat. student ed.), Belmont, Calif. (Duxbury), 2004.

**Responsible for Module:**
Alexander Hübner alexander.huebner@tum.de

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

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

# Module Description

## CS0003: Production of Renewable Fuels | Production of Renewable Fuels

Version of module description: Gültig ab winterterm 2023/24

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The learning results are going to be proven in form of a written exam of 90 Minutes. Along the problem set, it is checked whether the student is able to understand, improve and assess industrial processes for the production of renewable fuels. No aids permitted.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basic knowledge in chemistry, Fundamentals in Thermodynamics (e.g., Grundlagen der Thermodynamik), Fundamentals in Process Engineering (e.g., Introduction to Process Engineering)

**Content:**
Requirements for fuels, linkage of energetic and chemical value chains, fossil fuel production as reference, balancing and assessments (Well-to-Wheel), Hydrogen and methanol economy, alternative fuels on C1-basis, fisher-tropsch fuels, OME, bio-based oil fuels, biodiesel, green diesel, HEFA, bio-based alcohols, legislation of fuels.

**Intended Learning Outcomes:**
This module aims at making the students familiar with the industrial processes to produce renewable fuels. They are able to set up material and energy balances of these processes and assess their sustainability. Limitations with respect of raw material supply, energetic efficiencies and market requirements are understood. The students understand the interactions of fuel market and energy market.

**Teaching and Learning Methods:**
The module consists of a lectures and exercises. Contents of the lecture shall be imparted in speech and by presentation. To deepen their knowledge students are encouraged to study the literature and examine with regards to content the topics. In the exercises learned theory is applied with a practical orientation by means of arithmetic examples.

**Media:**
Hybrid live lectures & asynchronous mini-videos allowing distance learning, lecture Script and exercises via online platform, excursions to fuel production plants

**Reading List:**
• Jacob A. Moulijn, Michiel Makkee, Annelies E. van Diepen: Chemical Process Technology, Wiley (2013).
• George Olah et al.: Beyond Oil and Gas: The Methanol Economy, Wiley VCH (2006)
• Volker Schindler: Kraftstoffe für morgen: Eine Analyse von Zusammenhängen und Handlungsoptionen, Springer (1997)
• Martin Kaltschmitt, Hans Hartmann, Hermann Hofbauer: Energie aus Biomasse; Grundlagen, Techniken und Verfahren,SpringerVieweg (2016)
• Jochen Lehmann, Thomas Luschtinetz: Wasserstoff und Brennstoffzellen, Springer (2014)

**Responsible for Module:**
Burger, Jakob; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Production of renewable fuels (Tutorial, Straubing) (Übung, 2 SWS)
Burger J [L], Burger J, Groh D, Rosen N

Production of renewable fuels (Tutorial, Garching)  (Übung, 2 SWS)
Burger J [L], Burger J, Groh D, Staudt J

Production of renewable fuels (Lecture, Straubing) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Staudt J

Production of renewable fuels (Lecture, Garching)  (Vorlesung, 2 SWS)
Burger J [L], Burger J, Staudt J
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0008: Enzyme Engineering | Enzyme Engineering [EE]

Version of module description: Gültig ab summerterm 2022

| Module Level: Master | Language: English | 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:**
To proof whether the students are able to show ways to optimize enzymes in their properties and to perform this methodically, a written examination takes place with a duration of 60 minutes and a written seminar report must be created.The total grade consists of the written exam grade (67%) and the grade of the seminar report (33%).

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
This course aims to convey molecular biology and protein chemistry approaches to optimize enzymes especially by variation of the primary structure. Essential contents are: analysis of the limitation at the molecular level, rational methods, computer-based methods, evolutionary and combined procedures, high-throughput methods, robotics. The seminar aims to convey basic bioinformatical tools used in rational enzyme design such as ligand docking, energy minimization and rational introduction of mutations. These methods will be practiced on real enzymes and used to generate improved enzyme variants for a specific engineering target.

**Intended Learning Outcomes:**
After participating in the lecture the students will be able to indicate options for the improvement of technically limited enzymes, to estimate the necessary effort for these improvements and they own the theoretical ability to put these improvements into practice. After having participated in the seminar the students are able to use different bioinformatical tools for rational enzyme design and are able to evaluate the results of the generated informatical predictions.

**Teaching and Learning Methods:**
The lecture will be performed as ex-cathedra teaching to provide the students with all necessary fundamentals. In addition, the students review single methods and procedures by themselves e.g. based on current scientific literature and present this review to each other in a presentation. In the seminar, the students will be guided through the single steps of a rational enzyme engineering approach with the help of a script. The results of these steps will be summarized in a written report to put the single steps into a larger context.

**Media:**
PowerPoint, lecture script, scientific publications

**Reading List:**
Recommendations:
"Directed Enzyme Evolution: Screening and Selection Methods" (Methods in Molecular Biology) and "Directed Evolution Library Creation: Methods and Protocols" (Methods in Molecular Biology), both Frances H. Arnold, George Georgiou (publisher), Springer, Berlin
"Protein Engineering Protocols" (Methods in Molecular Biology), Katja M. Arndt and Kristian M. Muller (publisher), Springer, Berlin.

**Responsible for Module:**
Sieber, Volker; 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

## CS0019: Chemistry of Enzymes | Chemistry of Enzymes [COE]

Version of module description: Gültig ab winterterm 2022/23

| Module Level:<br>Master | Language:<br>English | Duration:<br>one semester | Frequency:<br>winter/summer semester |
|---|---|---|---|
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>60 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
To proof whether the students are able to understand and to describe more complex enzymatic reaction mechanisms and deduce starting points for new enzymes from that, an oral examination takes place with a duration of 30 minutes.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
The lecture first gives an insight into the kinetic processes of enzymatic reactions and their descriptions. Then the katalytic mechanisms from a chemical point of view are presented and analyzed by means of enzymes of all six enzyme classes (e.g. acid/base catalysis in hydrolases, one-electron reactions, oxygenation, radical catalysis etc), whereby here more complex mechanisms are illuminated. The different coenzymes are introduced and their interaction with the substrates and the protein backbone is explained. For selected enzymes the mechanisms are presented in relation to the applications.

**Intended Learning Outcomes:**
After participating in the module sessions, students will be able to understand which complex catalytic mechanisms proceed in enzymes and how they are analyzed. This enables them to assess which chemical reactions are enzymatically possible and which non-natural modifications are necessary to establish new reactions. Thus, the students can for example open up the function of newly found enzymes and develop new enzymes

**Teaching and Learning Methods:**
The lecture will be performed as ex-cathedra teaching  to familiarize the students with all necessary basics. The lecture is interrupted by short exercises/question-answer units to stimulate independent, critical thinking. In the seminar, the students will acquire the mechanisms for selected enzyme systems in self-research, introduce them to their fellow students and solve in a group work concrete problems of varying complexity.

**Media:**
PowerPoint, script, task sheets

**Reading List:**

**Responsible for Module:**
Dr.-Ing. Ammar Al-Shameri

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

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

## Module Description

### CS0032: Seminar on Optimization Methods and their Application | Seminar on Optimization Methods and their Application [SemOMA]

Version of module description: Gültig ab summerterm 2023

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The examination consists of a written seminar paper as well as an oral presentation & discussion. The seminar paper should cover 15–20 pages and be written in the style of current publications of peer-reviewed journal articles. In addition to the seminar paper, optimization models and methods may have to be implemented in order to conduct numerical analyses, which will be handed in as a digital appendix. At the end of the module, students present their work in a 45 minutes presentation. Both parts (the written paper and the presentation) are weighted equally to the final grading.

**Repeat Examination:**

**(Recommended) Prerequisites:**
The module covers optimization models and methods and their application in operations research. To study these models and methods, methodological knowledge on optimization methods as obtained, e.g., in the module CS0098 (Operations Research) is required.

**Content:**
The seminar focuses on recent research developments on varying topics related to optimization methods and their application in operations research. Students learn to model practical problems arising in different areas of operations research as optimization problems and to solve the resulting problems using suitable methods. Thereby, mathematical optimization models and methods from areas such as (mixed-integer) linear programming and network optimization (e.g., shortest path or network flow problems) are used to solve relevant practical problems.

**Intended Learning Outcomes:**
The objective of the module is to equip the participants with the necessary skills for writing academic papers and tools for a successful master's thesis project.

Specifically, the aim is to be able to:
- Read and understand recent research contributions
- Pursue interesting and relevant research questions
- Conduct a literature study and/or numerical study and/or implementation concerning a specific topic
- Structure and organize research methods and results
- Write a seminar paper
- Present research findings and defend them in an academic discussion

**Teaching and Learning Methods:**
In an introductory session, the current theme of the module is explained by the lecturer and the various available seminar topics are elaborated in detail. Moreover, information on relevant literature for the problem settings is introduced, which forms the basis of the students' seminar papers. After the introductory session, students will work out their assigned topics independently own or in small groups by using their abilities of conducting literature research, mathematical modelling, programming, and quantitative analyses. Throughout the project, they receive guidance from a supervisor. Different milestones such as a preliminary outline of the seminar paper, first research results, and the final paper are to be achieved. Following the submission of the final paper, presentations and discussions of all students' seminar papers are conducted, where also presentation, moderation, and discussion skills are trained.

**Media:**
Research paper; presentation slides

**Reading List:**
F. Petropoulos et al. - Operational Research: Methods and Applications, Journal of the Operational Research Society, Volume 75, Issue 3, pp. 423-617 (2024)
M. Carter, C. C. Price, G. Rabadi - Operations Research: A Practical Introduction (2nd ed.), Chapman and Hall/CRC (2018)

**Responsible for Module:**
Thielen, Clemens; 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

## CS0104: Biogenic Polymers | Biogenic Polymers [Bioplar]

Version of module description: Gültig ab winterterm 2020/21

| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
|---|---|---|---|
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
During the seminar, students independently work on a topic from the field of biogenic polymers, and give an oral presentation. Group work is optional. Assessment requires an oral examination (30 minutes). Students demonstrate their knowledge of physico-chemical properties of biogenic polymers as well as possible applications. Students are able to develop options for chemical synthesis and analysis of physico-chemical properties of bioplastics. No further tools are allowed in the examination.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Successful participation in "Basics in Chemistry" and knowledge of materials and chemical compounds, or comparable knowledge on chemistry and physics.

**Content:**
The module deals with structure and function of natural bio-macromolecules (in particular polysaccharids and proteins). Furthermore, basics of biogenic polymers will bei discussed in the view of polymers holding potential for applications in future technology. The topic of chemical synthesis and derivatization of bioplastics for use in industry is introduced (e.g. cellulose derivatives). Special focus is set on the development of options for chemical synthesis and its competent application. Physico-chemical properties of bioplastics as well as their characterization is central to the lecture.
The seminar takes the form of a journal club with students independently work on reserach papers and their presentation to fellow students.

**Intended Learning Outcomes:**
After participation, students are able to classify different kinds of bioplastics with respect to their possible application. They are competent to evaluate the production processes of biopolymers used in technology and can classify them according to their profile of properties. The module enables students to decide on appropriate synthesis methods to meet specific requirements in the industry. Students will also be able to use physico-chemical analysis methods in a competent way.

**Teaching and Learning Methods:**
Lecture (talks given by teaching staff using PowerPoint media, books and additional written document), seminar (independent work on a topic including a presentation, peer instruction and constructive criticism)

**Media:**
Presentations, slide notes

**Reading List:**
Endres, H.J., Seibert-Raths, A., Technische Biopolymere, Carl Hanser Verlag, München, 2009

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Biogenic Polymers (Seminar) (Seminar, 1 SWS)
Zollfrank C [L], Helberg J

Biogenic Polymers (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Zollfrank C
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0143: Hydropower | Wasserkraft [HyPo]

Version of module description: Gültig ab winterterm 2023/24

| **Module Level:**<br>Master | **Language:**<br>German | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
|---|---|---|---|
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The basics of energy generation from hydropower are assessed in a written examination (60 minutes).

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basics in Mathematics and Physics
Basics in Energy Technology

**Content:**
"In-depth knowledge regarding energy generation from water power is taught in this module. The technologies used for this purpose will be presented from the following points of view:
• Physical basics
• construction types and system components
• Planning, erection and operation
• Power output and energy supply
In addition to technical features of plants, their effects on the environment as well as sustainability considerations are covered. Legal framework conditions as well as the economic aspects of using water power are discussed as well. "

**Intended Learning Outcomes:**
After completion of the module, students are able to characterize various types of plants for the use of hydropower. They can recognize and understand the plants from the point of view of energy and technology.

**Teaching and Learning Methods:**
The module consists of a lectures with integrated excercises. Lectures include talks and presentations as well as exercises. Students should be encouraged to study the literature and discuss about the topics. In addition, practical excercises with measurement equipment and an excursion may be included.

**Media:**
PowerPoint
Blackboard

**Reading List:**
Jürgen Giesecke, Emil Mosonyi: Wasserkraftanlagen. Springer, 2009. ISBN 978-3-540-88988-5

**Responsible for Module:**
Prof. Josef Kainz

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

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

# Module Description

## CS0147: Energy Efficient Buildings | Energy Efficient Buildings [EEB]

Version of module description: Gültig ab winterterm 2022/23

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Students demonstrate their knowledge and understanding of the differenct aspects of energy efficient buildings in form of a written examination (90 minutes). Students deliver definitions, describe and outline relevant processes, mechanisms and requirements of energy efficient buildings. Furthermore, students calculate different technical specifications and parameters based on provided practice-oriented examples.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basics of physics, Basics of energy technology

**Content:**
The course focuses on the variety of options for implementation and/or enhancement of energy efficiency in new and existing buildings. This includes an introduction to relevant expert knowledge of energy and ressource efficient building materials and construction. In addition, typical measures for the enhancement of energy efficiency in existing buildings will be presented and evaluated concerning ther sustainability. The second part of the module is concerned with renerwable energy based systems for heat and warm water provision of buildings. Specific advantages and disadvantages of the presented technologies will be discussed in regards to building and usage type. In addition to the presentation of individual measures, it will be analyzed how concepts for energy efficient buildings can be include in modern building infrastructure and on living quarter scale.

**Intended Learning Outcomes:**
"After successful completion of the module, students acquire in-depth understanding of  factors determining the energy efficiency of buildings and relevant legal requirements. Students can

evaluate the  sustainability of actions to enhance the energy efficiency of (existing) buildings. In addition, students can  understand as well as evaluate and explain advantages and disadvantages of systems for heat and warm water provision based on renewable energies in regards to building and usage type.

Students prepare short, practice-oriented tasks as homework in a project team (group work). Thereby, they acquire the ability to view and assess information within a limited period of time and solve practice-oriented questions. The edited information and results are passed on to the other participants accordingly with the focus on sharing results in the form of a written report as well as team work.

**Teaching and Learning Methods:**
The content is taught in lecturs and presentations. In addition, case studies and exercises will bei discussed. Students should bei encouraged to individual literature study and discussions on the theme.

**Media:**
PowerPoint, blackboard, videos

**Reading List:**
Bauer, M., Mösle, P., Schwarz, M. (201.): Green Building: Leitfaden für nachhaltiges Bauen. Springer Vieweg. Daten von Fachagenturen: BINE Informationsdienst, vom Bundesumweltministerium bzw. entsprechenden Landesministerien und anderen internationalen Organisationen.

**Responsible for Module:**
Vienken, Thomas; 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

## CS0149: Renewable Resources in Medicine | Renewable Resources in Medicine

Version of module description: Gültig ab summerterm 2023

| 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 Assessment consists of a written examination (90 minutes)

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Requirements for the successful participation is basic knowledge in chemistry, cell and microbiology, biochemistry, materials science and renewable ressources

**Content:**
The course provides basic knowledge on the human anatomy, cell biology on general and the cell membranes in particular. The interaction of materials with cell surfaces and tissue will be introduced. The general issues related to pharmacology and the fabrication of drugs from from renewable ressources will be discussed. The application of renwable resources as the main course topic in surgery, internal medicine, plastic and reconstructive surgery as well as wound dressings will introduced. Future tasks for the medical application of renewable resources are outlined. The legislative framework for application of medical products and fabrication will be discussed.

**Intended Learning Outcomes:**
The successful visit of this course enables the students to select materials from renewable ressources for relevant fields in medicine (skin, muscle, bone) and can particularly assess the valueof their applicability. They are able to apply the most important legislation in medical application and to validate the material reqeuiements for the application in humans (biocompatibility). They are able to identify and develop new concepts for sustainable materials

from renwable ressources in medicine due to their aquired medical, chemical and materials science knowledge and they can set the base for the potiental application of such materials.

**Teaching and Learning Methods:**
Lecture (talk by teaching staff) with media, seminar on case studies

**Media:**
Presentation, script, examples, case studies

**Reading List:**
The following literature is recommended: Buddy Ratner et al.: Biomaterials Science - An Introduction to Materials in Medicine, Elsevier

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

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

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

## Module Description

# CS0156: Material Application for Renewable Resources | Material Application for Renewable Resources

Version of module description: Gültig ab summerterm 2024

| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
|---|---|---|---|
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
During the seminar, students independently work on a selected topic from the field of biobased materials and give an oral presentation with PowerPoint-handout (min. 10 slides). Group work is compulsory (3 – 5 persons). The students will implement their own online survey and present the findings in the context of the relevant literature in the presentation (each student has to present 5 minutes). The oral presentation shall be assessed according to content of the PowerPoint-handout and rhetoric aspects. The PowerPoint-handout summarizes the relevant literature, data, and key findings. Weighting: PowerPoint-handout 1, oral presentation 1.
The seminar work is not part of the written exam. However, midterm bonus points can be achieved which will have an effect on the individual final grade (-0,3).

Assessment requires a written examination (90 minutes). Students demonstrate their knowledge of physico-chemical properties and possible applications of biobased materials, as well as their environmental impact. Students are able to develop options for chemical synthesis and production processes of biobased plastics. No further tools are allowed in the examination.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Successful participation in "Basics in chemistry " and “Biogenic Polymers”, as well as knowledge of materials and chemical compounds, or comparable knowledge of chemistry and physics.

**Content:**
Lectures give an overview the applications for biogenic resources in materials industry. Starting with the chemical composition and physic-chemical properties of the raw materials, the module introduces students to production and processing of biodegradable and non-biodegradable

bioplastics, as well as of natural fibre composites. It also covers material properties, relevant fields of application, their environmental impact, as well as current market trends.
In the seminar, students independently work on research papers and based on that, give a presentation to fellow students.

**Intended Learning Outcomes:**
After successful participation, students are able to assess opportunities and barriers for the application of biobased plastics, as well as their environmental impact compared to conventional plastics. Above all, they are competent to select suitable feedstocks, classes and types of materials, as well as processes to meet the technical requirements of a specific target product, having lower environmental impact at the same time.

**Teaching and Learning Methods:**
Lecture (talks using PowerPoint slide media, books and additional written material), seminar (independent work on a selected topic with subsequent presentation, peer instruction and constructive feedback).

**Media:**
Presentations, slide notes

**Reading List:**
Endres, H.J., Seibert-Raths, A., Technische Biopolymere, Carl Hanser Verlag, München, 2009
Pickering, K. L. (Hrsg.): Properties and performance of natural-fibre composites, CRC Press, Boca Raton 2008
Lewin, M.(Hrsg.): Handbook of Fibre Chemistry, Marcel Dekker, New York, 1998

**Responsible for Module:**
Fink, Bettina; 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

### CS0164: Basics of Numerical Methods and Simulation | Basics of Numerical Methods and Simulation [NumS]

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Examination shall be done in the form of a written test. As an aid the materials (lecture slides, example programs) used during the lecture may be employed. The students show by solving programming tasks that they know the basics of Matlab and are able to employ it to implement simple numerical methods. They apply these methods to specific technical problems in case studies. In doing so, they also demonstrate their capability to discern which way to solve a problem is appropriate.
Exam duration: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
WZ1600 Physics, CS0 Mathematics

**Content:**
- Basics of programming using Matlab/Simulink
- simple numerical methods: Systems of linear equations, numerical integration & differentiation, finding zeros,
- numerical solution of differential equations
- application of methods by using case studies (e.g. mechanical and electric systems)
- basics of optimization

**Intended Learning Outcomes:**
After having participated in the module units the students understand basic concepts of various numerical methods. They can apply these methods to case studies presented in the course methods using self-created programs in Matlab/Simulink. In doing so, they have also learned

to implement different solutions and discern how appropriate to the problem they are. In simple cases, they are also able to evaluate their results in terms of plausibility and accuracy.

**Teaching and Learning Methods:**
The module consists of one lecture and an associated session of exercises. Contents of the lecture shall be imparted in a speech and deepened through independent preparation of exercises by the students. Processing of exercises is often done by independent preparation of programming tasks.

**Media:**
Presentations,  writing on the board, demonstration of programmes/scripts

**Reading List:**

**Responsible for Module:**
Kainz, Josef; 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

## CS0255: Current Topics in Machine Learning and Bioinformatics | Current Topics in Machine Learning and Bioinformatics [CTMLBI]

Version of module description: Gültig ab summerterm 2023

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>60 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
The learning outcomes are tested by a graded seminar presentation with a duration of approximately 45 minutes including a discussion with the audience. The seminar allows the students to assess the extent to which they can summarize a complex scientific work in the field of Machine Learning or Bioinformatics correctly and present it to an audience in a comprehensible and convincing way. Furthermore, to assess the skill to quickly understand, review and critically discuss recent research in these fields, the active participation and discussions of the other seminar presentations will be considered as well.

**Repeat Examination:**

**(Recommended) Prerequisites:**
Knowledge in Machine Learning and Bioinformatics (e.g. Bioinformatics (WZ1631) and Artificial Intelligence for Biotechnology (CS0012)) is expected

**Content:**
At the beginning of this course, introductory lectures about current topics in Machine Learning and Bioinformatics will be given. The following topics are treated exemplarily:
- Ensemble learners
- Neural Networks (Basic concept, Feedforward neural networks, Recurrent Neural Networks, Convolutional Neural Networks, Generative Models)
- Green Artificial Intelligence
- Genome-wide Association Studies
- Phenotype Prediction
- Protein-Protein Interaction Network Analysis
- Protein Prediction

- Data Driven Biotechnology
In this course, we will also talk about recent Machine Learning and Bioinformatics research and how it can support sustainability, e.g., by guiding downstream research with data-driven approaches. Furthermore, we will also look at Green Artificial Intelligence, a research direction that aims to make resource-intense AI development more sustainable. After introductory lectures, each student will analyze a recent scientific paper in these research areas in self-study and present it to the course. Active participation and discussions in all the other presentations is expected.

**Intended Learning Outcomes:**
After successful participation in this module, students will be able to understand and present recent research in Machine Learning or Bioinformatics. They are enabled to analyze recent scientific publications in one of the two fields. Based on this knowledge, they can summarize and present a scientific paper in a concise and understandable way as well as to discuss recent research in Machine Learning or Bioinformatics. Furthermore, students know about current research directions in these scientific fields and know how current Machine Learning and Bioinformatics research supports sustainability.

**Teaching and Learning Methods:**
At the beginning of this course, introductory lectures to current Machine Learning and Bioinformatics topics will provide additional and necessary fundamentals to understand recent scientific publications. Furthermore, each student will analyze a recent research paper in one of the two fields in self-study and present it to the course to train the ability to understand advanced concepts. Beyond that, for further training of these skills, the paper presentations will be discussed in the course.

**Media:**
Slide presentation, blackboard, discussion forums in e-learning platforms

**Reading List:**
Pattern Recognition and Machine Learning, Christopher M. Bishop
Deep Learning, Ian Goodfellow, Yoshua Bengio, Aaron Courville

**Responsible for Module:**
Prof. Dr. Dominik Grimm, Florian Haselbeck

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

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

# Module Description

## CS0260: Energy and Economics | Energy and Economics [EUW]

Version of module description: Gültig ab summerterm 2022

| Module Level: | Language: | Duration: | Frequency: |
|---|---|---|---|
| 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 examination will take the form of a written test (60 minutes). The students prove that they can understand and answer questions and the connections between the energy conversion, the conversion of renewable raw materials, the energy supply in general and the current energy-political and economic situation. Group work can be included and be part of the exam.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Prior participation and passing of the fundamentals of Thermodynamics module is required for participation in the Energy and Economics module.

**Content:**
The module deals with the basics of energy sources, climate change and the technology of the heat, electricity and fuel market and the use of renewable raw materials, including an introduction to simple technical systems and current topics on the energy industry. It also deals with electricity trading, CO2 trading and the current situation of various energy technologies.
In exercises small examples are calculated to the economy (production costs of heat and power of plants (e.g. combined heat and power plants).

**Intended Learning Outcomes:**
By participating in the module, students will be able to understand the energy sources and simple principles of energy conversion into heat and electricity. They can perform simple economic assessments of energy systems and understand related market mechanisms of the electricity and heat market.

**Teaching and Learning Methods:**
The module consists of a lecture with exercises. The contents of the lecture are conveyed in the lecture and through presentations.

**Media:**
Presentations, exercise

**Reading List:**
Kaltschmitt, M.; Hartmann, H.; Hofbauer, H.: Energie aus Biomasse, 2. Auflage, Springer, ISBN 978-3-540-85094-6, 2009
Karl, J.: Dezentrale Energiesysteme, Oldenbourg, ISBN 3-486-27505-4, 2004/

**Responsible for Module:**
Gaderer, Matthias; 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

## CS0261: Phytopharmaceuticals and Natural Products | Phytopharmaceuticals and Natural Products [Phytopharm]

Version of module description: Gültig ab summerterm 2022

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
Knowledge of the covered topics of phytopharmaceuticals and natural products compounds is assessed in a written examination (90 minutes). In addition, students are required to explain the medicinal effects of medicinal plants in the examination using examples.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Organic and anorganic chemistry, botany

**Content:**
Content of the lecture:
-definition of medicinal plants and phytopharmaceuticals
-position of phytopharmaceuticals in pharmacology
-compounding (tea drugs, soluble extracts, sCO2 extracts, steam destillation, pure substances)
-effect-determining components and frequent mechanisms (inflammation cascade, infections, coagulation system, neurotransmission, digestive system)
-typical medicinal plants grown in Europe
-international trade in medicinal plants
-important classes of compounds (terpenes, steroids, coumarine, alcaloids, vitamins, saccharides)
-quality determination and typical methods (chromatography)
-falsification and chemotype (chemical race)
-drug regulator affairs (authorisation, documents)
-use of medicinal plants in practice

**Intended Learning Outcomes:**
After their participation, students can explain the production of phytopharmaceuticals derived from typical medicinal plants (from collection to quality control). They can relate chemical compounds and medical effects of typical examples.

**Teaching and Learning Methods:**
The lecture takes the form of oral presentation given by teaching staff with the help of PowerPoint media, books and other written material.

**Media:**
PowerPoint presentation and printed handout. Laboratory equipment for experiments.

**Reading List:**
Deutschmann, F., Hohmann, B., Sprecher, E., Stahl, E., Pharmazeutische Biologie, 3 Bde., G. Fischer Verlag, 1992

**Responsible for Module:**
Riepl, Herbert; 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

## CS0263: Geothermal Energy Systems | Geothermal Energy Systems [GeoE]

*Potentials of geothermal energy supply*

Version of module description: Gültig ab winterterm 2022/23

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Students demonstrate their knowledge and understanding of geothermal systems and their potential for energy supply in form of a written examination (90 minutes). Students deliver definitions, describe and outline relevant processes for the geothermal energy supply. Furthermore, students calculate different technical specifications and parameters based on provided practice-oriented examples.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Successful completion of the module "Basics in engineering" and "Introduction to Energy conversion and Energy economy". Knowledge and interest in Geology and Physics are valuable.

**Content:**
The course focuses on the variety of options for geothermal energy supply. This includes an introduction to relevant geological expert knowledge such as formation of the earth, earth's structure, geothermal heat sources, the rock-cycle as well as mechanism of subsurface heat transport. After an introduction to deep geothermal exploration (drilling, drilling technology and related risks) the focus of the course is placed on shallow geothermal energy and use of ground-coupled heat pump systems.

This includes the design and working principle of a heat pump system and its integration in technical building equipment as well as the analysis of their ecological and economic sustainable operation on living quarter scale. The analysis is also done with regards to existing technical guidelines as well as legal boundary conditions. Practice-oriented tasks will be used to

demonstrate and critically evaluate the basic planning steps of heat pump systems and obtaining the relevant parameters. Existing and innovative geothermal exploration concepts will be analyzed and discussed against this background.

**Intended Learning Outcomes:**
After successful completion of the module, students acquire in-depth understanding of geothermal energy systems including relevant geological and hydrogeological processes. Students can evaluate the ecological as well as economic sustainability of geothermal heat source systems. They can test plausibility of dimensioning ground-coupled heat pump systems and understand, explain and comprehend heat transport processes and regeneration processes within the subsurface.

Students prepare short, practice-oriented tasks as homework in a project team (group work). Thereby, they acquire the ability to view and assess information within a limited period of time and solve practice-oriented questions. The edited information and results are passed on to the other participants accordingly with the focus on sharing results in the form of a written report as well as team work.

**Teaching and Learning Methods:**
The content is taught in lectures and presentations and strengthened by case studies and exercises. If applicable, the module is complemented by an excursion.

**Media:**
Lecture, Power Point presentation, blackboard, case examples, topics prepared and presented by participants.

**Reading List:**
Bayerisches Staatsministerium für Landesentwicklung und Umweltfragen (2005): Oberflächennahe Geothermie.
Bauer, M., Freeden, W., Jacobi, H., Neu, Th. (Hrsg.) (2018): Handbuch Oberflächennahe Geothermie. Springer Spektrum, 1. Auflage.
Stober, I. & Bucher, K. (2014): Geothermal Energy. Springer Spektrum, 1st edition.
Hölting, B., Coldewey, W.G. (2013): Hydrogeologie. Springer Spektrum, 8. überarbeitete Auflage.
Dassargues, A. (2018): Hydrogeology: Groundwater Science and Engineering, CRC Press, 1st edition.
Grotzinger, T. & Jordan, T. (2017): Press/Siever Allgemeine Geologie. Springer Spektrum, 7. Auflage
Grotzinger, T. & Jordan, T. (2014): Understanding Earth. W.H. Freeman & Company, 7th edition

**Responsible for Module:**
Vienken, Thomas; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Geothermal Energy Systems (Vorlesung mit integrierten Übungen, 4 SWS)

Vienken T [L], Vienken T
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0264: Polymer Processing | Polymer Processing [PolyProc]

*Processing of polymers intro plastic parts*

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
The content and learning objectives of the lecture are examined at the end of the semester in a written test (90 min). An oral pre-test containing safety relevant laboratory work issues must be carried out before the individual pratical course. A written report on the practical course consisting of approximately five pages must be submitted. The written report is an ungraded student achievement.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Polymer chemistry, polymer physics, rheology fluid mechanics, Biogenic Polymers

**Content:**
The lecture deals with unit operations, basic techniques and processes of plastic material processing, e.g. compounding, extrusion, injection molding, plastic part forming processes and also typical applications. In addition, methods for characterizing thermal and mechanical properties are presented. One focus here is the connection between the processing parameters and the end-use properties. The acquired knowledge is deepened in the accompanying practical course. Injection molding and extrusion tests are carried out and the test specimens are then characterized with regard to their thermal, optical and mechanical properties. Additional foci will be laid on the chemistry, structure and classification of polymers and plastic parts. The lecture also deals with the physical properties of polymers and plastic materials involving materials science. Characterization of the mechanical and thermal properties and their effects on processing, viscosity, viscoelastic behavio will be discussed

**Intended Learning Outcomes:**
In addition to the chemical-physical basics of polymeric materials, this module imparts the methodical knowledge about classic and modern innovative processing methods of polymeric materials. The students are able to sensibly classify plastic materials, their manufacture and use them for specific applications. The basics for the production technology of plastic materials are acquired. After successfully completing the module, students are able to select and use methods for processing plastic. They will be able to assess sustainability aspects of the polymer production process in terms energy consumption and materials use. Through practical work, the competence for the meaningful use of testing and characterization methods of polymer materials is acquired.

**Teaching and Learning Methods:**
Lecture (lecture by teaching staff with Power Point slide media, books and other written material), laboratory practical course (experimentation of the students under supervision)

**Media:**
Power Point slide presentations; Drawing and writing on a black board; Laboratory equipment for experimentation

**Reading List:**
Polymer Engineering; Technologien und Praxis; Peter Eyerer, Peter Elsner, Thomas Hirth
Polymer Extrusion; Chris Rauwendaal
Extrusion: The Definitive Processing Guide and Handbook; Harold F. Giles, Jr.
Einführung in die Kunsstoffverarbeitung; Michaeli, W.
Werkstoffkunde der Kunststoffe; Menges, G.

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Polymer Processing (Practical) (Praktikum, 1 SWS)
Zollfrank C [L], Helberg J

Polymer Processing (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Helberg J
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0266: Sustainable Chemistry | Sustainable Chemistry

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
The examination will take the form of a written test (60 minutes). In this examination the competence for the evaluation of chemical processes and for the derivation of optimization strategies shall be proven. No aids are permitted in the written examination. In order to additionally check whether the students are able to communicate scientific topics in front of an audience and whether they are able to critically deal with problems in individual steps, the results of the processing of the case studies are presented in the form of a 20-minute presentation alone or in a group. This presentation is ungraded study achievement.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Successful participation in the module "Basics in chemistry" or comparable knowledge in chemistry.

**Content:**
The module teaches basic principles of sustainable chemistry. Focus is set on the evaluation of chemical processes in view of efficiency, atom economy and amount of waste. In addition, optimizsation strategies related to catalytical methods, raw material and energy efficiency are discussed. Students individually prepare current topics related to sustainable chemistry and present them in the seminar.

**Intended Learning Outcomes:**
By attending the module events, students are able to highlight the principles of sustainable chemistry. Students can analyze the efficiency and waste quantities of chemical reactions and evaluate various alternative processes. Furthermore, they are able to discuss further chemical aspects of the conversion of renewable raw materials into valuable products. Through the

independent development of case studies, the students master all the steps that are important in the critical examination of problems (consideration of the example, development of criteria for evaluation, assessment, presentation of the results to an audience).

**Teaching and Learning Methods:**
Lecture with board addresses and presentations: Basic development and derivation of technical contents; seminar with written tasks. Consolidation of the technical learning contents through learning activity of the students themselves, e.g. through independent development of case studies from the field of sustainable chemistry.

**Media:**
Presentation, script, examples

**Reading List:**
Stanley E. Manahan: Green Chemistry, ISBN: 0-9749522-4-9

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Sustainable Chemistry (Seminar) (Seminar, 1 SWS)
Zollfrank C [L], Helberg J, Zollfrank C
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0267: Biological Materials | Biological Materials

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Understanding of the course contents and their application will be tested in a written exam of 90 minutes duration. In detail, the students are required to describe the physical and chemical foundations of the formation, as well as relations between the hierarchical structure and properties, of typical biological materials. Further, the transfer of this knowledge to technological applications and to the design of novel biologically inspired materials, as covered in the course, is a test subject. Lecture notes are not permitted.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge in geometry and chemistry

**Content:**
The module Biological Materials in Nature and Technology covers important biological functional materials, based on basic materials scientific knowledge. This encompasses such materials that fulfill, in their biological system, or in a technological application, either in native state, or modified, one or more specific functions. Differences and similarities to classical engineering materials are pointed out. In addition to the modules Bioinspired Materials and Instrumental Analysis, the students learn important methods for structural and property analysis. After a presentation of the classification of biological materials, students- are taught the basic correlations between hierarchical structuring and macroscopic properties. As the most important complex, the influence of hierarchical structuring on the mechanical properties of materials will be discussed. The students learn, which modes of failure can occur in biological systems and how they are influenced. In this context, modification routes for biological materials are shown and discussed.

**Intended Learning Outcomes:**
After successful completion of the module, the students are enabled to name criteria for a proper usage of biological materials. They can name specialized methods for the analysis of hierarchical structures and the derived material properties and explain the correlations between structure and external properties. Further, they are able to describe tailored modification routes for biological materials.

**Teaching and Learning Methods:**
Lecture with discussion and case studies

**Media:**
Presentation, slides

**Reading List:**
Structural Biological Materials: Design and Structure-Property Relationships. Eds Elices M, Pergamon-Elsevier Science Ltd, Oxford, (2000).
Fratzl P & Harrington MJ. Introduction to Biological Materials Science. Wiley VCH, Weinheim, Germany, (2015).

**Responsible for Module:**
Van Opdenbosch, Daniel; 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

## CS0305: Research Excursion Master | Research Excursion Master

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>irregularly |
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>60 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
Passed/not passed:
The module is passed when the students deliver a learning portfolio consisting of the following elements::
1. 2 written pages or 20' presentation on preparatory work for the excursion. The form and the due date will be specified in the kick-off session.
2. At least two topical contributions to the excursion (topical input, interviews, questions on presentations and during site visits, discussion contributions;
3. 5-10 PPT slides reflecting the findings based on a case study visited during the excursion. The due date will be specified in the kick-off session;
4. Final report of case studies and results of the workshop;

All four elements of the learning portfolio have to be delivered to pass the module.

**Repeat Examination:**

**(Recommended) Prerequisites:**
Prerequisites may be defined by the professors / lecturers offering the excursion, dependent on the chosen destination / topic. They will be announced with the announcement of the excursion 1 month before the start of lectures in the semester in which the excursion is offered, at the latest.

**Content:**
The research excursion deals with individual topics from modules and / or the study programs for which it is designed. On an individual basis, professors and lecturerers from these modules / study programs offer the research excursion to a topic or place of their choice.

A bullet point list with typically 10-12 entries will be provided by the professors and lecturers with the announcement of the research excursion 1 month before the start of lectures in the semester in which the excursion is offered, at the latest.

After the excursion the results of the applied methodologies are presented and discussed in a workshop. Key findings and the results of the workshop are included in a final excursion report by the students.

**Intended Learning Outcomes:**
The excursion aims to support the scientific profile building of students and the acquisition of scientific, practical and social competencies and the application to case studies visited during the excursion. It supports the competence acquisition in other modules and / or the study programs in general. The students get practical insights into the topical field of the research excursion, deepen their comptencies in this field regarding ongoing research and apply their competencies to real case studies in practice.

In particular, the intended learning outcomes are the following:
- Select relevant scientific and practical information and recall it for for visits of organizations, cities and talks with experts and stakeholders,
- Prepare questions regarding the state-of-knowledge, open research questions and practical relevance and discuss these with fellow students,
- Discuss research and practical knowledge with stakeholders,
- Recognize the implementation of research and practical knowledge in the organisations / sites visited,
- Reflect on the state of implementation of theoretical knowledge in practice,
- Discuss with fellow students and supervisors gained insights and compare it with their expectations,
- Perform structured interviews and talks with experts and stakeholders in practice
- Apply methodologies from theoretical lectures and exercises on practical organizations

**Teaching and Learning Methods:**
The research excursion consists typically of the following elements (teaching, learning and application of methods):
- Kick-off session: To achieve a good get-to-know, brief the students about the module contents, course and required performance an interactive in-presence workshop will be carried out. This covers presentations, and interactive elements such as role games etc.
- Individual work and feedback: In order to prepare for the on-site visits the students carry out own literature research on the excursion topics. To document their learning progress and to be able to share the results they summarize their findings in written form. A presentation of the contents in front of the fellow students is an optional element. In this process, they are supervised, receive materials and continuous feedback.
- On-site visits: 3-5 day research trip with site-visits, presentations, discussions with stakeholders, interviews of experts etc. This part will be specified in the specific program of the research

excursion and can due to the variety of possible destinations and topics not be specified further at this point.
- Individual work: the students will reflect their learnings in written form,
- Workshop: the students will present and discuss their findings in a workshop to gain practical experience for their future working conditions and formulate a final excursion report.

**Media:**
Digital projector, board, flipchart, online contents, recent scientific journal publications, equipment and utilities demonstrating production processes in practice

**Reading List:**
Topic related reading, especially articles in international peer reviewed journals, will be provided during the course of the module.

**Responsible for Module:**
Prof. Cordt Zollfrank Prof. Hubert Röder Prof. Magnus Fröhling

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

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

## Module Description

### SOT86701: EuroTeQ Collider. Enhancing Connections for Sustainable Futures (MSc) | EuroTeQ Collider. Enhancing Connections for Sustainable Futures (MSc)

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
During this module, students must complete following tasks: producing a presentation that provides information on the project concept development and implementation, as well as a final report, charting the progress of their work/research over time. These assessments will evaluate a) the success of the project and b) the learning success of the students in oral and written form. Students will be graded based on the active participation in a group project (20%), a final presentation of project results (60%) and a final project report (20%). These examination requirements will assess the success of the project, but also examine the learning success of the students in oral and written form.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
This module is aimed at all students enrolled in a Bachelor or Master program at the TUM; it is thus designed as an interdisciplinary venue which brings together a range of scientific perspectives. No specific prior knowledge is required; however, its project-based character requires high levels of intrinsic motivation and the willingness to actively participate in a project.Please register for this course via TUM Online. If you have any questions or problems to register, please send an email to euroteq@ja.tum.de

**Content:**
"Enhancing Connections for Sustainable Futures" aims to promote an integrated approach based on three main areas: People, Nature, and Technology. In the "People" domain, the focus is on empowering and enabling communities. This involves connecting people's needs and aspirations through technology, including digital solutions, in various areas such as wellbeing,

health, culture, etc. In the "Nature" realm, the call concentrates on the conscious use of nature and the consideration of its resources. This includes examining interactions in ecosystems, safeguarding biodiversity and nature conservation, as well as utilizing renewable energies. Within the "Technology" sphere, the emphasis is on establishing efficient connections through technology, both digital and physical. This encompasses various fields such as information technology, logistics, transportation, manufacturing, communication, etc. Overall, the call aims to promote sustainable connections that enable meeting human needs, protecting the environment, and leveraging innovative technologies to achieve these goals.

The Technical University of Munich (TUM) joint forces within eight leading universities of science, technology and business to foster the European spirit in a EuroTeQ format to promote innovative engineering education across Europe. Together, we are created the first EuroTeQ Collider in 2022. Now, the journey goes into the second round. The Collider is an innovative learning format with the aim of bringing students together with vocational trainees and professionals to tackle challenges. The theme for the period 2024-2026 is “Enhancing connections for sustainable Futures”. The goal is to connect participants with different profiles and personalities to boost creativity, innovation, shared understanding, enabling participants to imagine new approaches and design disruptive solutions.

The module is a seminar that gives students the opportunity to apply their knowledge on topics related to the theme “Enhancing connections for sustainable Futures”. Within this overarching theme, we are offering challenges on three different topic-domains, namely:

• People – e.g., empowering and enabling communities, connecting people's needs and aspirations through technology (including digital solutions) in different areas such as wellbeing, health, culture, etc.
• Nature – e.g., on the conscious use of nature, taking into account environmental resources and the relationship of organisms to the environment: interactions in the ecosystem, safeguarding biodiversity and nature conservation, use of renewable energies, etc.
• Technology – e.g., efficient connections through technology, both digital and physical, in various areas such as information technology, logistics, transportation, manufacturing, communication, etc.

Within every topic domain, interdisciplinary (and international) teams of students, vocational trainees and professional learners are formed to develop solutions towards a desirable future, test and validate tools and create prototypes of their solutions. A selection of the best projects will be presented in a major high-level event, the EuroTeQaThon.

**Intended Learning Outcomes:**
After completion, all EuroTeQ Collider participants will be able to:
- Select and apply appropriate design, engineering and business approaches and tools to create an innovative and science-based solution to a real-life challenge.
- Develop a profound interpretation of a complex, real-life problem and its context using a system-thinking approach, considering multiple perspectives.

- Develop a problem-driven, creative, and integrative design, demonstrated by a concrete prototype that balances desirability, feasibility, and viability.
- Use disciplinary knowledge and expertise in an inter-disciplinary team to develop an innovative and scientifically sound solution in a European context.
- Communicate your ideas, at different levels of elaboration, via several mediums in an international context to a diverse set of stakeholders.
- Define and regularly reflect on personal and team development.

**Teaching and Learning Methods:**
A range of teaching & learning techniques will be applied:
- (pre-recorded) videos and online presentations, with podcasts and interviews, Q&A Sessions with experts
- This module is focusing on service-learning and project-based learning
- After a set of introductory sessions which provide input on the core topics but also project management, students will work on their projects in groups. Progress will be determined through project presentations during the semester, continuous feedback from the instructors, as well as peer-to-peer feedback.
- Presentational skills will be further facilitated through the requirement to present the results
- As students and professionals will work together in a joint effort, all participants will not only improve their technical skills but also enhance their soft skills such as team spirit, flexibility to work in multicultural environments, and design thinking, which are also very important in professional life.

**Media:**

**Reading List:**

**Responsible for Module:**
Finger, Peter; Dipl.-Ing. agr. (Univ.)

**Courses (Type of course, Weekly hours per semester), Instructor:**
(SOT82701, SOT86701) EuroTeQ Collider. Enhancing Connections for Sustainable Futures (Seminar, 4 SWS)
Wester A ( Finger P, Lehmann D, Schmid H )
For further information in this module, please click campus.tum.de or here.

# Electives TUM (max. 18 ECTS) | Electives TUM (max. 18 ECTS)

## Module Description

## WZ4202: Political and Social Perspectives of Renewable Resources | Political and Social Perspectives of Renewable Resources

Version of module description: Gültig ab winterterm 2015/16

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
Oral presentation of the group project work, review paper for a scientific journal. The learning outcomes are assessed by a group project work concerning a selected topic related to the political and social perspectives of renewable resources. Therefore students have to prepare a scientific paper for an international journal of their choice and give a short oral presentation about the work done for the paper, similar to what would be expected in a 15 minute conference presentation.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Knowledge of sustainable resources (materials and energy). Scientific writing.

**Content:**
In the lectures a number of examples of societal aspects of Sustainable Resource programs will be presented and discussed. Backgrounds are global developments such as urbanization, the rise of countries like China and India, resource availability and technological developments. Case studies deal with tropical forestry and pros and cons of tropical hardwood uses, urban planning, vernacular architecture and the use of renewable resources We take a tour around the world and look at social housing programs in Europe, Brazil and South-East Asia. Furthermore we look at successes and failures in the German/European energy policies in comparison to the United States.

**Intended Learning Outcomes:**
After this course, students should be able to:

1. Develop SR stimulation programs on country or regional level and priority analysis of renewable resource applications
2. Assess priorities for development and application of renewable resources in countries with different levels of development
3. Critically analyze existing SR programs taking into account social values of stakeholders,
4. Assess impacts of global developments such as urbanization and UN-policies on SR.

**Teaching and Learning Methods:**
Discussion and creativity sessions. Project work evolving in a scientific paper for a journal of choice. Oral presentation.

**Media:**
Lectures, UN-policy notes, Discussion and Creativity sessions.

**Reading List:**
Tba

**Responsible for Module:**
van de Kuilen, Jan Willem; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Political and Social Perspectives of Renewable Resources (Vorlesung, 4 SWS)
van de Kuilen J [L], van de Kuilen J, Khaloian Sarnaghi A
For further information in this module, please click campus.tum.de or here.

# Module Description

## BV460017: Hydro Power und Energy Storage | Wasserkraft und Energiespeicherung

Version of module description: Gültig ab winterterm 2022/23

| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
|---|---|---|---|
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>60 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
The module examination is a written exam (60 minutes, open book, allowed tools: notes, print medias (books, printed slides…), non-programmable calculator; not allowed tools: technical devices, communication). It consists of theoretical questions and practical calculations, each about 50%.

Furthermore, they prove that they can design a water power station in concept and dimensioning as well as the state-of-the-art technologies for energy storage.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Bachelor's level knowledge in hydraulic engineering, e.g.
• "Basic Module Hydraulic and Water Resources Engineering"
• "Supplementary Module Hydraulic and Water Resources Engineering"

**Content:**
The module provides in-depth knowledge of principles, methods and technologies for calculation and management of sustainable generation of energy from hydropower.

• types of hydro power stations, specific requirements of large and small hydro power
• elements of hydro power installations
• hydro turbines: turbine types, application ranges
• stream turbines: fundamentals, turbine types, application range
• energy conversion in hydro turbines - physical fundamentals

• planning of hydro power stations: hydrological surveys, layout, power plan
• needs and requirements for energy storage
• fundamental options for power storage
• properties of storage technologies, pros and cons, application ranges, potential, development state, project examples
• pumped storage plants: fundamentals, electromechanical equipment, new approaches

**Intended Learning Outcomes:**
After successful participation in the module, students will be able
• to describe, identify and assess established and newly proposed technologies of hydropower and energy storage
• to explain and assess the physical foundations of the energy conversion as well as the fundamental approach in planning hydropower projects
• to evaluate hydropower project plans and to perform planning themselves.

**Teaching and Learning Methods:**
• lecture style
• practical examples
• coordinated moodle tests (voluntary)

**Media:**
• PowerPoint presentations with film sequences and computer animations
• blackboard exercises
• moodle tests (voluntary)
• lecture notes in moodle

**Reading List:**
See lecture notes

**Responsible for Module:**
Prof. Dr. Nils Rüther (nils.ruether@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**
Hydro Power and Energy Storage (Vorlesung, 2 SWS)
Rüther N
For further information in this module, please click campus.tum.de or here.

# Module Description

## ED150010: Sustainable Mobile Drivetrains | Nachhaltige Mobile Antriebssysteme

Version of module description: Gültig ab winterterm 2022/23

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

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

**Description of Examination Method:**
Die Modulprüfung erfolgt in Form einer schriftlichen Klausur (Prüfungsdauer: 90 min). Die Studierenden sollen in begrenzter Zeit die Konzepte nachhaltiger mobiler Antriebssysteme auf verschiedene Frage- und Problemstellungen anwenden. Damit soll z. B. überprüft werden, ob die Studierenden bewerten können, wie eine konkrete Ausgestaltung eines Antriebssystems in verschiedensten Fortbewegungsmitteln ausgeführt werden kann oder ob die Studierenden die Grundlagen der Funktionsweise und des Aufbaus von Kolbenmotoren, elektrischen Antriebssträngen und von Antriebssträngen mit Brennstoffzelle verstehen.
Als Hilfsmittel zugelassen sind: Schreibutensilien, Lineal und ein nicht programmierbarer Taschenrechner.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
None

**Content:**
Themenschwerpunkte:
* Nachhaltigkeit und Klimaschutz
* Gestaltung nachhaltiger Mobilität
* Grundlagen der Fahrzeugtechnik
* Grundlagen der Fahrzeugantriebe
* Verbrennungsmotoren mit nachhaltigen Kraftstoffen
* Elektrische Antriebssysteme (Batterie, Inverter, e-Motor)
* Antriebssysteme mit Brennstoffzellen
* Energie und Mobilität

**Intended Learning Outcomes:**
Nach erfolgreicher Teilnahme am Modul "Nachhaltige Mobile Antriebssysteme" sind die Studierenden in der Lage...
... zu verstehen, wie und warum der Klimawandel eine Transformation hin zu nachhaltiger Mobilität erfordert
... einzuordnen, wie sich diese Transformation auf die traditionellen Verkehrsmittel und ihre Antriebe auswirken wird
... zu bewerten, wie eine konkrete Ausgestaltung eines Antriebssystems in verschiedensten Fortbewegungsmitteln ausgeführt werden kann
... die wichtigsten mobilen Antriebssysteme nach ihren jeweiligen Vorteilen, Nachteilen und Einsatzgebieten zu beurteilen
... die Grundlagen der Funktionsweise und des Aufbaus von Kolbenmotoren zu verstehen
... die Grundlagen der Funktionsweise und des Aufbaus elektrischer Antriebsstränge zu verstehen
... die Grundlagen der Funktionsweise und des Aufbaus von Antriebssträngen mit Brennstoffzelle zu verstehen
... einzuordnen, welches Antriebssystem für eine gegebene Anwendung am besten geeignet ist
... zu bewerten, welchen Einfluss die Rolle des Energieträgers auf die Nachhaltigkeit des gesamten Antriebssystems ausübt
... grundlegende Zusammenhänge zwischen Energie, Mobilität und Antriebssystem kritisch zu hinterfragen
... einfache aber wirkungsvolle Grobabschätzungen der wichtigsten Eigenschaften moderner Antriebssysteme vorzunehmen

**Teaching and Learning Methods:**
In der Vorlesung werden die Grundlagen nachhaltiger mobiler Antriebssysteme anhand von Vortrag, Präsentation und Tablet-PC vermittelt. Die Theorie wird durch Anwendungsfälle erläutert und mit Hilfe von einfachen Rechenbeispielen gefestigt. Erfahrungen und Probleme aus der Praxis werden vorgestellt, diskutiert und gerechnet.
Damit sollen die Studierenden beispielsweise lernen, zu bewerten, wie eine konkrete Ausgestaltung eines Antriebssystems in verschiedensten Fortbewegungsmitteln ausgeführt werden kann sowie die Grundlagen der Funktionsweise und des Aufbaus von Kolbenmotoren, elektrischer Antriebsstränge und von Antriebssträngen mit Brennstoffzelle zu verstehen.
Alle Lehrmaterialien sowie weiterführende Informationen werden kostenfrei in der Vorlesung verteilt oder werden online zur Verfügung gestellt. Sprechstunden werden flexibel angeboten.

**Media:**
* Vortrag
* Präsentation
* Tablet-PC mit Beamer
* Online-Lehrmaterialien

**Reading List:**
Zapf, Martin: Kosteneffiziente und nachhaltige Automobile. 2. Auflage. Wiesbaden: Springer Vieweg, 2021.

Doppelbauer, Martin: Grundlagen der Elektromobilität. Wiesbaden: Springer Vieweg, 2020.
Schreiner, Klaus: Verbrennungsmotor - kurz und bündig. Wiesbaden: Springer Vieweg, 2017.
Klell, Manfred: Wasserstoff in der Fahrzeugtechnik. 4. Auflage. Wiesbaden: Springer Vieweg, 2018.

**Responsible for Module:**
Jaensch, Malte; Prof. Ph.D.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Nachhaltige Mobile Antriebssysteme [ED150010] (Vorlesung, 3 SWS)
Jaensch M [L], Jaensch M, Heindl J
For further information in this module, please click campus.tum.de or here.

## Module Description

### ED160007: Lithium-Ion Battery Production | Lithium-Ionen-Batterieproduktion [VLBP]

*Lithium-ion battery production*

Version of module description: Gültig ab winterterm 2021/22

| **Module Level:** Master | **Language:** German | **Duration:** one semester | **Frequency:** winter 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:**
The module examination takes place in the form of a written exam (examination duration 90 minutes). By means of comprehension questions, calculation tasks and transfer tasks, the students should prove that they have an understanding of the basic processes of lithium-ion battery production and that they can apply this understanding. The content of the exam consists of comprehension questions from the lecture as well as various tasks, some of which are more advanced, based on the content of the exercises accompanying the lecture. Only a non-programmable calculator is allowed as an aid.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Prior experience in electrical energy storage and production engineering is recommended. Prior knowledge in chemistry and process engineering is not required but helpful.

**Content:**
The lecture provides an insight into all process steps in the production of lithium-ion batteries. The focus is on the holistic view of the process chain, including important process parameters and influencing factors.
Detailed content:
- Structure of the lithium-ion cell, electrochemical and electro-technical fundamentals, energy storage methods
- Material and cell systems on component level, process chains of battery production, safety aspects, production environment
- Mixing processes for anodes and cathodes (stirring, mixing)

- Coating processes for anodes and cathodes (slot die, doctor blade, cascade die) and process variants
- Calendering processes (porosity analysis, defect patterns)
- Packaging and assembling (cell formats, application areas)
- Packaging and contacting (ultrasonic welding, friction stir welding, laser welding)
- Filling and wetting (electrolyte properties, electrochemical impedance spectroscopy)
- Formation and aging (passivation layer, charge/discharge rate and lifetime test)
- Electrochemical characterization, cost models, quality criteria
- Recycling (material recycling, second life of the battery cell)
- Innovative process steps (laser patterning, mechanical prelithiation) and alternative lithium-ion battery technologies (solid-state batteries, sodium-ion battery)

**Intended Learning Outcomes:**
After participating in the module, students will be able to understand basic interrelationships of lithium-ion battery production and to evaluate them.
After successful participation in the module, students will be able to:
- Demonstrate a basic understanding of the material systems processed
- Evaluate the mode of operation of a lithium-ion battery on the basis of measurement characteristics
- Know, analyze and classify all process steps in lithium-ion battery production and their variants
- Understand basic interrelationships in lithium-ion battery production
- To develop requirements for the respective processes and suitable plant technology
- Evaluate typical fault patterns and assess their possible causes and consequences for the product
- Characterize the properties of a battery cell using cell tests and correlate them with the manufacturing processes
- Know, understand and apply important methods of quality assurance
- Understand future technologies and their special features with regard to the product and be able to recognize and classify trends

**Teaching and Learning Methods:**
In the lecture, the theoretical basics of lithium-ion battery production are taught by means of lecture and presentation. With the explanations from the lecture and corresponding self-study, the students learn to understand, evaluate and develop all process steps of lithium-ion battery production. Students supplement the course material by studying the recommended literature on battery production and related areas.
Students independently solve questions and tasks related to the content of the course using practical examples. In the exercise, sample tasks are calculated, discussed and debated together with the students. This is intended to ensure that the students can independently acquire the learning outcomes and transfer performance.

**Media:**
Presentations, videos and other illustrative material are used for visualization. Via the eLearning portal, the participants receive all exercise documents for preparation, which are then discussed

in the exercises. Furthermore, the lecture materials from the lecture are made available to the participants.

**Reading List:**
Recommended basic literature:
Korthauer, Reiner (Hrsg.): Handbuch Lithium-Ionen-Batterien. Springer-Verlag Berlin Heidelberg 2013. ISBN: 978-3-642-30653-2
Gulbinska, Malgorzata K. (Hrsg.): Lithium-ion Battery Materials and Engineering. Springer-Verlag 2014. ISBN: 1447165470
Julien, Christian (Hrsg.): Lithium Batteries, Science and Technology. Springer International Publishing 2015. ISBN: 9783319191089

In addition, further literature references are recommended in the individual lectures for in-depth study.

**Responsible for Module:**
Daub, Rüdiger; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Lithium-Ionen-Batterieproduktion (Vorlesung, 2 SWS)
Daub R [L], Daub R, Jaimez Farnham E, Lindenblatt J

Lithium-Ionen-Batterieproduktion (Übung, 1 SWS)
Daub R [L], Daub R, Lindenblatt J
For further information in this module, please click campus.tum.de or here.

# Module Description

## **MW2245: Think. Make. Start. | Think. Make. Start.** [TMS]

*Build innovative products of your ideas in 10 days!*

Version of module description: Gültig ab winterterm 2024/25

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

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

**Description of Examination Method:**
The module examination consists of a project work incl. written documentation (approx. 10 pages) and presentation (10 min), in which the students develop a new product in a group project and present their idea for founding a company on this basis. The individual performance is assessed to what extent the students are able to develop a product with market potential by means of an iterative approach to prototypical implementation. The assessment also includes the ability to work in a team, the ability to make well-founded design decisions and the completeness and conclusiveness of the concept, taking into account social relevance, novelty and innovation. As part of the project work, in addition to documentation, there is a final oral presentation. Through the presentation, students are expected to show whether they can demonstrate their ability to act as a competent team.

**Repeat Examination:**

**(Recommended) Prerequisites:**
The basic requirement is a willingness to engage with new learning methods, approaches, disciplines and ways of working. Cross-role experience in project management, product development (Design Thinking, TRIZ, Systems Engineering, etc), interdisciplinary teamwork, communication skills, creativity and problem solving skills are an advantage. A lot of emphasis is placed on practical experience.

For the "Problem Expert" role, experience in the following areas is an advantage:
- User Testing, Requirements Engineering, Interviewing, Human-Centered Design, Design, Visualisation, Use Case Definition, UX/UI Design, marketing, market research, benchmarking, design thinking.

For the "Tech Developer" role, experience in the following areas is an advantage:
- Hardware (mechanical): design, manufacturing (workshop/makerspace), prototyping, CAD/CAM.
- Hardware (electronic): embedded systems engineering, microcontrollers, sensors/actuators, Arduino, Raspberry, circuitry, board design, metrology, BUS protocols, prototyping, closed-loop/ open-loop control, robotics
- Software focus: Backend development, databases, frontend development, machine learning, web development, app development, embedded systems

For the "Business Developer" role, experience in the following areas is an advantage:
- Business Plan/Strategy/Design, Marketing, Sales, Interviewing, Finance & Accounting, Business Law & Regulations, Entrepreneurship.

The number of participants is limited and there will be an application process.

**Content:**
During the interdisciplinary team project, students work methodically, purposefully and agilely on a development project to develop innovative new products with the intention of successfully launching them on the market. Current needs and problems from social, technological and economic systems are identified, analysed and validated in the interdisciplinary team. In doing so, they cooperatively solve challenges that arise from constraints from the different disciplines. They generate suitable market hypotheses and product ideas at an early stage and interact with initial potential customers/users. They iteratively create prototypes and evaluate their hypotheses with them in experiments.

For more information, visit www.thinkmakestart.com and www.tms.tum.de.

**Intended Learning Outcomes:**
After participating in the module “Think.Make.Start.” the students are able to
- reproduce the principles of user-centered design
- apply methods of product development (e.g., Design Thinking) to a challenge of their choice
- develop important hypotheses involving relevant stakeholders (customer, user, ...) through proper planning with "purposeful prototyping"
- examine the relevance of a problem and develop a solution collaboratively in an interdisciplinary team
- design a prototype based on the acquired design methods and analyzed insights
- lay the foundation for one's own business start-up by identifying a start-up idea or team.

**Teaching and Learning Methods:**
"THINK. MAKE. START." is a two-week, practice-oriented, interdisciplinary and competitive teaching format in which students from all faculties can participate (credits are given individually related to the study program). It is organised by the different chairs of TUM, TUM ForTe, and UnternehmerTUM. They get access to the high-tech workshop Makerspace and budget to transform their own ideas into real prototypes (mechatronic products). Learning outcomes are achieved through the following teaching and learning methods:

- Milestones to be achieved, team roles to be held and predetermined course structure provide the roadmap for the project.
- Coaching and teaching expertise in prototyping, business validation, agile development, design thinking, systems engineering, lean startup and user-centred design.
- Teaching the basics of interdisciplinary collaboration through a role concept (Business Developer, Tech Developer, Problem Expert).
- All participants work in interdisciplinary teams (10 teams of 5 students each) and are encouraged to become active themselves and learn through practical experience (hands-on learning).
- Each team pursues a real business idea chosen for the seminar. Special attention is given to really understanding the customer and verifying the solution approach, through questioning, observation, prototyping or expert discussion.
- Using prototyping to bridge the gap between thinking and doing.
- Reflecting on one's own results and approach supports project decisions.
- The teams present their projects to a jury on DemoDay and present the prototypically implemented product ideas to guests from industry, the start-up scene and research.

**Media:**
Project manual, presentations, hand-outs, posters, videos, examples.

**Reading List:**
Esch Franz-Rudolf (2012) Strategie und Technik der Markenführung, 7. Auflage, Vahlen

Faltin, Günter (2008): Kopf schlägt Kapital, Hanser

Halgrimsson (2012): Prototyping and Model Making for Product Design (2012)

Kalweit Andreas, Paul Christof, Peters Sascha, Wallbaum Reiner (2012) Handbuch für Technisches
Produktdesign, Material und Fertigung, Entscheidungsgrundlage für Designer und Ingenieure, 2. Auflage, Springer

Kelly, Tom (2016): The Art of Innovation

Lindemann, U (2007): Methodische Entwicklung technischer Produkte - Methoden flexibel und situationsgerecht anwenden. 2. Auflage

Münchener Business Plan Wettbewerb: Handbuch Businessplan-Erstellung, München http://www.evobis.de/coaching/handbuch/

Malek, Miroslaw / Ibach, Peter K. (2004): Entrepreneurship, Dpunkt Verlag

Moore, Geoffrey A. (2002): Crossing the Chasm, Harpercollins

Osterwalder, Alexander / Pigneur, Yves (2010): Business Model Generation: A Handbook for

Ries, Eric (2011): The Lean Startup

Savoia, Antonio (2019): The right It

Timmons, Jeffry A. / Spinelli, Stephen (2009): New Venture Creation, 7thedition, McGraw, Hill Professional

UnternehmerTUM (2011): Handbuch Schlüsselkompetenzen, 7. Auflage

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

**Courses (Type of course, Weekly hours per semester), Instructor:**
Think.Make.Start. (Praktikum, 4 SWS)
Zimmermann M [L], Tong Y, Hohnbaum K, Amm M, Büchner B, Baur C, Bien S, Mogk J
For further information in this module, please click campus.tum.de or here.

# Module Description

## WZ1590: Climate Change Economics | Climate Change Economics

Version of module description: Gültig ab summerterm 2024

| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
|---|---|---|---|
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
There will be a written exam (Klausur) of 90 minutes at the end of the semester. The students will be asked to demonstrate, within the stipulated amount of time using predefined methods and resources, their ability to outline the challenges climate change poses to regulators, propose pragmatic solutions and strategies as well as ways of implementing them. This will be based on the competencies acquired from the relevant literature of economic modeling, theories of climate change, and their understanding of the course content. The written exam is an appropriate assessment method to evaluate the degree to which the students understand the theoretical framework of climate change implications as well as provides an opportunity for them to put forward arguments based on existing theory.

In addition, there is the option of taking a voluntary mid-term assignments as course work in accordance with APSO §6, 5. For this, a presentation (15 min) has to be given.
The module grade can be improved by 0.3 by passing the course work if this better characterises the student's performance level on the basis of the overall impression and the deviation has no influence on passing the examination. No repeat date is offered for the mid-term performance. When retaking a failed module examination at the next possible examination date, successfully passed mid-term assignments will be taken into account.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge:
• Micro Economics (Welfare Economics)
• Environmental Economics
• Resource Economics

**Content:**
This course covers the trends in current and future climate change and their effects on economic and social outcomes.

The lectures cover the following topics:
1. Introduction to the Basic Science of Climate Change
- The students will learn about the scientific themes of global climate change and the economic dimension of the phenomenon.
2. Basic Economics
- The students will learn how a market economy can be efficient and socially optimal as well as about the prospects of externality.
3. Optimal Emission Levels
- The students will learn of the optimal abatement path and its uncertainty with respect to damages as well as Integrated Assessment Models (IAMs).
4. Intra-generational equity in climate policy
- The students will learn about how to account for equity across space (intergenerational equity) when deriving optimal emission levels.
5. International Environmental Agreements
- The students will learn about the dynamics behind common strategies towards achieving some form of optimal emission level.
6. Policy Instruments
- The students will learn about diverse instruments such as quality-based approach and Pigouvian Tax.
7. Regulation via Prices vs. Quantities
- The students will learn what circumstances will a regulator prefer prices over quantities and vice versa.
8. Credit-based Mechanisms
- The students will learn about how to deal with countries that do not want to commit but have a high potential for low-cost reductions.
9. German Climate Policy
- The students will learn about German Climate Action - strategies and policies
10. European Union Emission Trading Scheme - EU ETS

**Intended Learning Outcomes:**
After successfully completing the module, students are able to:
• Evaluate economic models related to climate change.
• Understand theoretical models of climate change regulations as well as policies that affect emission levels.
• Comprehend the complexity, uncertainty and possibilities associated with optimal emission level.
• Analyze appropriate instruments for emission levels that are efficient and cost-effective.
• Understand different forms of climate agreements and climate action strategies that are currently being implemented

**Teaching and Learning Methods:**
The course consists of lectures (2 SWS) and seminars (2 SWS). The lecture forms the basis for the subsequent discussion within the seminar on climate change issues from an economic perspective. The content of the module is expected to be transferred to the students in an interactive learning manner (including discussions in the lectures but especially intensive discussions in the seminar) where, among others, emission reduction instruments are scrutinized. This encourages the students to independently and self-reliantly study the literature guided by a structured framework.

**Media:**
PowerPoint, flipchart, internet portals, online reports etc.

**Reading List:**
Bréchet, T., & Eyckmans, J. (2009). Coalition theory and integrated assessment Modelling: Lessons for climate governance. Global Environmental Commons: Analytical and Political Challenges in Building Governance Mechanisms.
Rohling, M., & Ohndorf, M. (2012). Prices vs. quantities with fiscal cushioning. Resource and Energy Economics, 34(2), 169-187.
MacKenzie, I. A., & Ohndorf, M. (2012). Optimal monitoring of credit-based emissions trading under asymmetric information. Journal of regulatory economics, 42(2), 180-203.
Hake, J. F., Fischer, W., Venghaus, S., & Weckenbrock, C. (2015). The German Energiewende–history and status quo. Energy, 92, 532-546.
Climate Action Plan 2050 Principles and goals of the German government's climate policy. https://www.bmu.de
/fileadmin/Daten_BMU/Pools/Broschueren/klimaschutzplan_2050_en_bf.pdf
EU ETS Handbook. https://ec.europa.eu/clima/sites/clima/files/docs/ets_handbook_en.pdf

**Responsible for Module:**
Sauer, Johannes; Prof. Dr. agr.

**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 Technology | Electives in Management and Technology

## Module Description

### CS0125: Plant and Technology Management | Plant and Technology Management [PTM]

Version of module description: Gültig ab winterterm 2020/21

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

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

**Description of Examination Method:**
Written exam (90 minutes): By solving problems from the thematic field of the module students have to prove their understanding of the management of industrial plants and technologies, their ability to techno-economic assessment and optimization methods and their analytical and verbal skills in the field. In the solution of the problems they need to demonstrate their ability to analyse technical systems, assess them from an economic point of view and apply techno-economic methods to solve planning and optimization problems arising in the life cycle of these plants.
In addition, they need to show that they are able to discuss the application of these methods in practice and to derive further research needs. Learning aids: pocket calculator.

Alternative: For smaller groups (<15 students) parts of the examination can be held in form of a case study. In this case studies, students have to demonstrate in a group work that they acquired the above mentioned abilitites by solving problems of practical relevance. This acknowledges the complexity of real world problems and the necessity to solve these in (interdisciplinary) team works. With the case study solution students have to provide a statement of the individual contributions to the solutions. Weighting: 1:1.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
-

**Content:**
The module contains units covering the following topics:
• Introduction to Plant and Technology Management
• Life cycle of industrial plants
• Analysis and modelling of industrial production systems
• Project management in engineering
• Network and facility location planning
• Investment estimation
• Cost estimation
• Plant and process optimisation
• Maintenance and repair
• Quality Management
• Re-location, dismantling and recycling

**Intended Learning Outcomes:**
The students are able to solve techno-economic analysis, planning, and optimisation problems associated with the life cycle of industrial plants. This comprises also linked topics of technology assessment and management. After completion of this module the students are able to identify and characterise these problems and structure them. Further, they are able to determine needed data and apply suitable methods for the solution of the problems. They discuss the achievements and shortcomings of these methods for a practical application. They are able to transfer these contents to an application in practice.

**Teaching and Learning Methods:**
Format: Lecture with tutorial to introduce, train and deepen the contents of the module.

Teaching / learning methods:
- Media-assisted presentations
- Group work / case studies with presentation
- Individulal assignments and presentation
The teaching and learning methods are combinded specifically for the treated topics. Typically, a thematic impulse or overview is given with a media-assisted presentation. Individual or group work assignments provide the possibility to apply the acquired competencies, to repeat and deepen these as well as to prepare the transfer to other fields.

**Media:**
Digital projector, board, flipchart, online contents, case studies

**Reading List:**
Empfohlene Fachliteratur:
1. Chauvel (2003): Manual of Process Economic Evaluation, Edition Technip
2. Couper (2003): Process engineering economics, Marcel Dekker Inc
3. Geldermann (2014): Anlagen- und Energiewirtschaft

4. Goetsch/Davis (2015): Quality Management for Organizational Excellence: Introduction to Total Quality, Pearson
5. Mobley/Higgins/Wikoff (2014): Maintenance Engineering Handbook, McGrawHill
6. Peters/Timmmerhaus/West (2003): Plant Design and Economic for Chemical Engineers, McGrawHill
Weitere Literaturempfehlungen werden in den Veranstaltungen gegeben.

**Responsible for Module:**
Magnus Fröhling

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

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

# Module Description

## CS0126: Advanced Seminar in Circular Economy and Sustainability Management | Advanced Seminar in Circular Economy and Sustainability Management [ASCESM]

Version of module description: Gültig ab winterterm 2024/25

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Term paper: Students have to write a scientific paper on the given topic (15-20 pages). In doing so they have to show that they are capable to find relevant literature, structure a problem, solve it, and document the results of the process in a scientific paper.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
-

**Content:**
"The module deals with actual topics from Circular Economy and Sustainability Management. These differ from semester to semester. Topics will be announced at the end of the preceeding semester.

**Intended Learning Outcomes:**
The seminar aims at enabling students for scientific work. After passing the module the sutdents are able to find, structure and analyse relevant literature, solve the problem scientifically, discuss the solution critically, summarize the work in a term paper, hold a scientific presentation, and discuss and defend their work. Thereby the students acquire in-depht knowledge on a current topic from the thematic field of circular economy and sustainability management.

**Teaching and Learning Methods:**
Seminar: after an introduction on the topic the students carry out a literature research, structure the problem, identify solution approaches, apply these. They summarize their findings in a term

paper and a scientific presentation. In this process they are supervised, receive materials, thematic introductions, advise in scientific work and continuous feedback in the seminar sessions. The seminar closes with a final presentation.

Teaching / learning methods:
- Kick-off session: media-assisted presentation
- Individual work and feedback
- Interim presentations / workshops
- Final presentation
- Computer lab exercises using LCA software systems and Life Cycle Inventory Data bases.

**Media:**
Digital projector, board, flipchart, online contents, recent scientific journal publications, computer lab

**Reading List:**
Recommended reading:
• Gastel B; Day R A (2017): How to write and publish a sicentific paper, Cambridge University Press
• Glasman-Deal H (2009): Science Research Writing For Non-Native Speakers Of English: A Guide for Non-Native Speakers of English, Imperial College Press
• Skern T (2011): Writing Scientific English: A Workbook, UTB

Topic related reading, especially articles in international peer reviewed journals, will be provided in the kick-off meeting of the module.

**Responsible for Module:**
Fröhling, Magnus; Prof. Dr. rer. pol.

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

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

# Module Description

## CS0123: Advanced Seminar in Behavioral Economics | Advanced Seminar in Behavioral Economics

Version of module description: Gültig ab winterterm 2024/25

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The examination consists of a written seminar paper and an oral presentation with discussion. The seminar paper should cover 15-20 pages and is written in the style of a journal article. At the end of the module students present their work in a 30 minutes presentation. Weighting: Seminar paper 2, Presentation 1. The seminar paper demonstrates the student's ability to summarize the literature, explain research methods, present research findings and discuss them approbriately.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
-

**Content:**
This advanced seminar focuses on recent developments in Behavioral Economics. After being introduced to adequate research themes in the area of behavioral economics, students explore the academic literature on a chosen topic and develop their own research question. The topics are typically related to human behavior in an economic context and potential behavioral interventions.
Potential topics are:
-Green Nudges
-Social Comparison
-Choice Architecture

**Intended Learning Outcomes:**
The objective of the module is to equip the participants with the necessary skill and tools for a successful master thesis project.

Specifically, students will learn to:

- Read and understand recent research contributions
- Develop and pursue interesting research questions
- Conduct a literature review
- Eventually, design and conduct an experimental or empirical study
- Write a seminar paper in which they summarize the literature and explain research methods and results
- Present research findings and defend them in a discussion

**Teaching and Learning Methods:**
In an introductory session, the theme of the seminar is introduced and elaborated in detail.
The introduction will also introduce the relevant behavioral economics literature. Based on the introduction, students will develop their own research question and decide on the adequate research methods. During the term students have to reach different milestones (e.g., choose a topic, choose a research method, collect data, outline their paper, write the paper, present the results) on specific dates. Following the submission of the seminar paper, students will present and discuss their research question and findings. During all stages of the seminar students will be assisted by the lecturer(s).

**Media:**
Research papers; presentation slides

**Reading List:**
Cartwright, E. (2018). Behavioral economics. Routledge.
Davis, D. D., & Holt, C. A. (2021). Experimental economics. Princeton university press.
Additional current research articles will be provided during the seminar

**Responsible for Module:**
Goerg, Sebastian; Prof. Dr. rer. pol.

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

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

## Module Description

# CS0112: Advanced Seminar in Supply and Value Chain Management | Advanced Seminar in Supply and Value Chain Management

Version of module description: Gültig ab winterterm 2023/24

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The examination consists of a written seminar paper, implemented optimization or simulation models as well as an oral presentation & discussion. The seminar paper should cover 15-20 pages and is written in the style of current publications of peer-reviewed journal articles. Accompanied with the seminar paper models have to be implemented to conduct numerical analyses, which will be handed in as a digital appendix. At the end of the module students present their work in a 45 minutes presentation. Weighting: 1:1

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Recommended: One module in the field of Supply Chain Management

**Content:**
The advanced seminar focuses on recent research progress on varying topics in service operations, e.g. omni-channel retailing, online retail management. Students identify strategic and operational relationships between supply chain management, marketing and service functions. Thereby, empirical research methods (such as regression models) are applied as well as mathematical optimization and simulation models (such as mixed-integer programming or discrete event simulation) to identify best practice relationships. Several topics with applications in assortment planning, last mile logistics, transportation, inventory management and procurement are available.

**Intended Learning Outcomes:**
The objective of the module is to equip the participants with the necessary skill and tools for a successful master thesis project.

Specifically, the aim is to be able to:

- Read and understand recent research contributions
- Pursue interesting research questions
- Conduct a literature study and/or numerical study and/or implementation
- Structure and organize research methods and results
- Write a seminar paper
- Present research findings and defend them in a discussion

**Teaching and Learning Methods:**
In an introductory session, the current theme of the module is explained by the lecturer and the various available seminar topics are elaborated in detail. Also information on relevant literature for the problem settings is introduced, wich forms the basis of the students' seminar papers. After the introductory session, students will work out the topic on their own, by using their abbilities of conducting literature research, mathematical modelling, programming and analyses. Throughout the whole time, they receive guidance from a supervisor of the chair. Different milestones are to be achieved at specific dates, such as a preliminary outline of the seminar paper, first research results and the final paper. Following the submission of the final paper, presentations and discussions of all students' seminar papers are conducted, usually spanning one or several days, where amongst others also presentation, moderation and discussion skills are trained.

**Media:**
Research paper; presentation slides

**Reading List:**

**Responsible for Module:**
Alexander Hübner

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Seminar in Supply and Value Chain Management (Seminar, 4 SWS)
Hübner A [L], Hübner A, Riesenegger L, Tuma N
For further information in this module, please click campus.tum.de or here.

## Module Description

### WZ1138: Investment, Financing, Money and Capital Markets | Investition, Finanzierung und Kapitalmärkte

Version of module description: Gültig ab winterterm 2015/16

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:** | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Written examination (90 minutes): The students' knowledge is assessed with the help of a comprehensive and coherent case study. This includes students' ability to make and justify investment decisions as well as identify and justify a required financing for investment measures and a necessary use of guarantees.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge of (financing) mathematics

**Content:**
Investment calculation methods / techniques (static, dynamic), instruments for financing and credit insurance, and debtor related problems will be commented with the aid of case examples.
1. Introduction and basics of investment calculation
2.Taxes in investment calculation
3. Optimum replacement time for investment products
4. Uncertainty and sequential decisions
5. Optimum portfolios
6. Financial planning (involves a field trip)
7. Internal financing and self-financing (involves a field trip)
8. External financing (borrowing and own finance)
9. Loan securities
10. Simultaneous investment and programme planning (field trip)
11. Detailed real-life cases

The analysis of case examples is required to ensure that students can make investment decisions independently in their future professional life and will be able to identify the most suitable forms of financing. Ideally, this is not taught in actual classes but by e-learning (individual and group work; chat; fora, students monitoring their own learning)

Individual excursions (to companies and/or financial institutes) offer additional real-life experience.

**Intended Learning Outcomes:**
Students who have completed this module are aware of the principal methods of static and dynamic investment calculation, including their respective advantages and disadvantages. They can apply those methods to a business context, taking tax into account and using a spreadsheet program.
They are able to calculate and analyze investments offered by companies and derive recommendations for selecting the best offer (from a range of offers).
Students also recognise the potential of companies' internal and external financing (including on the capital market) and the key types of loan securities. They are able to undertake financial planning and evaluate how that might be implemented in a business setting as well as analyse the correct use of common securities relative to the value of the loan.

**Teaching and Learning Methods:**
Blended Learning inclucing 50 % presence required  (lectures, tutorials) and 50 % e-learning (via vhb) with the aid of online exercises, a case study and online tutorials.
Teaching of methods via our own e-learning system (developed for vhb) (starting SS2015) as well as in addition to traditional lectures requiring the students' presence.

**Media:**
Blackboard, PowerPoint,
e-learning (via vhb) (script, blog, exercise sets)

**Reading List:**
Bodmer, U.: Geldanlage und Finanzierung. Ulmer Verlag. Stuttgart. 1998.
Drukarczyk, J.: Finanzierung. 10. Auflage. Lucius & Lucius. Stuttgart 2008.
Sachs, G.: Technik der Finanzplanung. In: Hauschildt et al. (Hrsg.): Finanzplanung und Finanzkontrolle. Hagener Universitätstexte. Verlag Vahlen. München.
Zantow, R.: Finanzwirtschaft des Unternehmens; Pearson Verlag.
Zellweger, Th. und U. Fueglistaller: Finanzielles Risiko- und Investitionsverhalten von Familienunternehmen. In: Ernst Young AG und P. Bühler (Hrsg.):Schriften des Family Business Center der Universität Sankt Gallen.2005.
Zellweger, Th. und U. Fueglistaller: Rendite und Spielregeln in Familienunternehmen. In: Ernst Young AG und P. Bühler (Hrsg.):Schriften des Family Business Center der Universität Sankt Gallen.2005.

**Responsible for Module:**
Ulrich Bodmer (ulrich.bodmer@mytum.de)

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

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

# Module Description

## CS0171: Project Studies | Project Studies

Version of module description: Gültig ab summerterm 2021

| **Module Level:**<br>Master | **Language:**<br>German/English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
|---|---|---|---|
| **Credits:***<br>12 | **Total Hours:**<br>360 | **Self-study Hours:**<br>330 | **Contact Hours:**<br>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 in (30 pages + appendix) and a 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. Throughout this process, the students show that they can develop appropriate strategies to cope with 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. 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. The project study and its findings regarding the outlined problem set are based on students' academic knowledge gained through their study programs.

Examples of topics covered in the context of a project study include (non-exhaustive list):
- Analyzing potential sales volumes of a new market
- Identifying potential optimization actions regarding a supply chain
- Creating a financing concept for a company
- explaining problems of the logistic sector and developing appropriate optimization solutions
- Developing specific use cases for new electronic payment procedures and deriving appropriate product specifications
- Capturing and processing key performance indicators (KPIs) in controlling and the development of recommended actions
- Developing and conceptualizing a marketing strategy and deriving recommendations for implementation in the given market- or company environment

**Intended Learning Outcomes:**
After successful participation in the module, students are able to work on projects in a systematic and academic manner. Students are able to complete a project end-to-end throughout all project stages: problem definition, division of work/tasks, development of solutions, decision-making processes, realization, result presentation, and project report. Students obtain capabilities to apply theoretical concepts to the identified problem set and develop their analytical solution finding skills through team discussions. Students are able to exchange in a professional and academic manner within a team. They are able to integrate involved persons into the various tasks considering the group situation. Furthermore, the students obtain competencies in solution processes through their constructive and conceptual acting in a team. Students become able to manage resources, and deadlines through timely submission of the enumerated tasks in stages throughout their research projects.

**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. The supervision takes place through a kick-off meeting as well as an interim meeting. With regards to content the project study takes an approximate time of 9 weeks.

**Media:**
literature, presentations

**Reading List:**
Project Management Institute (2013): A Guide to the Project Management Body of Knowledge (PMBOK® Guide) - Fifth Edition

Further literature based on the specific topic

**Responsible for Module:**
Alexander Hübner

**Courses (Type of course, Weekly hours per semester), Instructor:**
Projektstudium | project studies (Orientierungsveranstaltung, 1 SWS)
Hübner A [L], Hübner A, Lex E
For further information in this module, please click campus.tum.de or here.

## Module Description

# CLA11317: Interdisciplinary Lecture Series Environment: Politics and Society | Ringvorlesung Umwelt: Politik und Gesellschaft

Version of module description: Gültig ab summerterm 2015

| | | | |
|---|---|---|---|
| **Module Level:**<br>Bachelor/Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>1 | **Total Hours:**<br>30 | **Self-study Hours:**<br>15 | **Contact Hours:**<br>15 |

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

**Description of Examination Method:**
A successful accomplishment of 9 academic performances is mandatory for the examination! The examination consists of a short PowerPoint presentation at the end of the semester. The presentation can be created alone or in groups of two. Everyone has to speak one minute.
The examination is ungraded.

**Repeat Examination:**

**(Recommended) Prerequisites:**

**Content:**
The lecture series Umwelt (environment) is an interdisciplinary, public lecture organised by the Environmental Department of the Studentische Vertretung (Student Representatives) of the TU Munich. Experts speak e.g. on technical environmental protection, health, consumer and climate protection. In the summer semester, it offers students the opportunity to learn about the political and social dimensions of current ecological topics and research results at a scientific level.

The lecture series Umwelt (environment) is offered in the winter semester in the module CLA11200 Ringvorlesung Umwelt: Ökologie und Technik (Lecture series on the environment: ecology and technology). It is only possible to gain given credits twice for the lecture series within each study program.

**Intended Learning Outcomes:**
Students are able to follow expert presentations on political and social dimensions of environmental problems and identify core theses and central facts.

**Teaching and Learning Methods:**
Lectures, presentations, discussions

**Media:**

**Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**
Out of Sight, Out of Mind? A Journey into the World's Hidden Realities (Ringvorlesung) (Vorlesung mit integrierten Übungen, 1,5 SWS)
Nogueira de Carvalho M, Pahl A, Slanitz A
For further information in this module, please click campus.tum.de or here.

# Module Description

## CLA31900: Lecture Series Environment - TUM | Vortragsreihe Umwelt - TUM

Version of module description: Gültig ab winterterm 2019/20

| | | | |
|---|---|---|---|
| **Module Level:**<br>Bachelor/Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>67 | **Contact Hours:**<br>23 |

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

**Description of Examination Method:**
The examination consists of a poster created in a group of 2-3 people connecting topics from at least two lectures. In order to collect material for the poster, participants have to organize themselves in discussion groups with 5-6 people.
Each discussion group will split into two groupes for the poster. At the end of the semester the poster has to be presented. Every member of the poster group has to speak one minute,
The grade will consist of the poster and its presentation.
Mandatory requirements for the examination
For the 3-ECTS course a successful accomplishment of 16 academic performances is mandatory for the examination!

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
The systematic integration of education for sustainable development at the university is an extremely complex challenge that can only be addressed through a plural and multi-perspective approach. Within the framework of the UNESCO World Programme of Action "Bildung für Nachhaltige Entwicklung“ (BNE; =Education for Sustainable Development), the interdisciplinary lecture series Umwelt - TUM takes place at the TUM Campus Garching, which deals with changing topics in the field of environmental sustainability.

It is organized by the newly founded branch of the environmental department AStA TUM at the Garching campus to promote sustainability awareness at TUM and to offer interested students the opportunity to deal with the topic in more detail.

**Intended Learning Outcomes:**
After successful participation in this module, students are able to understand lectures at a high scientific level and reproduce central statements. Students are able to comprehend analyses of sustainable development and are familiar with formulating their own positions and justifying them in discussions. Furthermore, they know where they can explore the topic of sustainability in more detail on campus, whether in the form of course offerings, internships, projects or thesis.

**Teaching and Learning Methods:**
It consists of six lectures and an organizational meeting at the beginning. Each lecture includes two 40-minute presentations, a 15-minute break and a subsequent 45-minute discussion with the speakers, which is realized in cooperation with the Zentrum for Schlüsselkompetenzen (Center for Key Competencies) of the Faculty of Mechanical Engineering.
The lectures and presentation slides will be uploaded to the online learning platform Moodle.
As homework, students will prepare a short report of the lectures and the discussion session. In addition, introductory and further literature will be addressed to enhance more detailed discussions of the lectures.

**Media:**

**Reading List:**

**Responsible for Module:**
Dr. phil. Alfred Slanitz (WTG@MCTS)

**Courses (Type of course, Weekly hours per semester), Instructor:**
Out of Sight, Out of Mind? A Journey into the World's Hidden Realities (Ringvorlesung) (Vorlesung mit integrierten Übungen, 1,5 SWS)
Nogueira de Carvalho M, Pahl A, Slanitz A
For further information in this module, please click campus.tum.de or here.

## CS_SoM: Electives SoM (max. 18 ECTS) | Electives SoM (max. 18 ECTS)

## Module Description

## WI000100: Advanced Microeconomics | Advanced Microeconomics

Version of module description: Gültig ab summerterm 2019

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

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

**Description of Examination Method:**
Students receive credit for the module after passing a multiple choice exam (written, 120 minutes). Students apply advanced concepts and methods of microeconomics (most notably of expected utility theory and game theory) to concrete decision problems and develop solutions. They show their ability to assess and evaluate decisions under uncertainty and asymmetric information (e.g. on insurance markets) as well as strategic interaction of decision makers (e.g. under oligopolistic competition). Hereby, students demonstrate their capacity for abstraction (thinking in economic models) and concretization (interpreting and applying the results of the model).

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
WI000021 "Economics I (Microeconomics)" OR WI001056 "Principles of Economics"

**Content:**
The module imparts advanced concepts and methods of microeconomics focussing on choice under uncertainty and strategic interaction. It examines markets under asymmetric information and imperfect competition.
• Expected Utility Theory
○ Risk Preferences
○ Insurance Markets
i) Adverse Selection
ii) Moral Hazard
• Game Theory
○ Nash Equilibrium

i) in pure and mixed strategies
ii) in simultaneous and sequential games
iii) in one shot and repeated games
○ Strategic Interaction in Oligopolistic Markets
i) Simultaneous and sequential quantity competition (Cournot, Stackelberg)

**Intended Learning Outcomes:**
Participation in the module will enable the students
• to apply expected utility theory in order to describe and evaluate decisions under uncertainty and/or asymmetric information. They will be capable of
○ analyzing the functioning of competitive insurance markets,
○ assessing market failure arising from asymmetric information,
○ solving problems of incentive compatibility.
• to apply game theory in order to analyze strategic interaction. They will be capable of
○ identifying and assessing equilibria,
○ practicing backward induction,
○ analyzing social dilemmas and coordination problems.
• to conceive policy advice und to evaluate concrete policy measures (e.g. in the field of social security or competition policy).

**Teaching and Learning Methods:**
The module consists of a lecture as well as an exercise course. The lecture content will be conveyed to the students by means of verbal presentation. The exercise course aims to encourage students to independently deliberate the presented economic problems, which are discussed in the lecture and in the relevant literature. In the exercise course, participants apply the acquired knowledge by solving exercises and implementing case studies, partially this process takes place in group work. Moreover, concrete issues raised by students are addressed and online polls are conducted at regular intervals. The polls contain multiple-choice questions similar to those presented in the exam and help course participants gauge their level of performance relative to others.

**Media:**
Text books, script, exercises, online polls, videos

**Reading List:**
- Gravelle, Hugh and Ray Rees (2004): Microeconomics, Pearson
- Jehle, Geoffrey and Philip Reny (2011): Advanced Microeconomic Theory, Pearson
- Kreps, David (1990): A Course in Microeconomic Theory, Princeton University Press
- Osborne, Martin (2004): An Introduction to Game Theory, Oxford University Press
- Shy, Oz (1996): Industrial Organization: Theory and Applications, MIT Press
- Zweifel, Peter and Roland Eisen (2012): Insurance Economics, Springer

**Responsible for Module:**
Feilcke, Christian; Dr. rer. pol.

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

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

# Module Description

## WI000231: Asset Management | Asset Management

Version of module description: Gültig ab summerterm 2021

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

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

**Description of Examination Method:**
The grading is based on an open-book e-test with a duration of 90 minutes. The e-test consists of calculations and multiple choice questions. By answering questions in multiple choice or text form, students have to show that they are able to understand the theory behind Asset Management (e.g. concept of utility and the calculation of basic utility measures, portfolio selection under various constraints, determinants of the capital asset pricing model and other factor models).
Moreover they show their ability to explain the basic models e.g. of portfolio theory.
By performing calculations and elaborating on theoretical considerations, students demonstrate their ability to evaluate and apply the methods presented in the module. They show that they are able to consider asset pricing models.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
MA9712 "Introductory Statistics" (Recommended)
MA9711 "Introductory Mathematic" (Recommended)

**Content:**
The target of the module is to familiarize students with the concept of Asset Management from a theoretical perspective. The module provides the theoretical foundation that is required to understand typical problems in Asset Management and illustrates how to solve these problems effectively by means of the appropriate tools (e.g. Excel Solver).

The following contents are addressed:

- Utility Theory and decisions under uncertainty

- Theory and application of basic models of portfolio theory with a particular focus on portfolio optimization under various contraints in the Markowitz mean-variance framework
- Theory and application of asset pricing models (e.g. Capital Asset Pricing Model, Arbitrage Pricing Theory)
- Theory and application of conditional asset pricing
- Portfolios Performance Measurement

**Intended Learning Outcomes:**
After successful completion of the module, students (1) understand the concept of utility theory (utility functions and link to risk attitudes) and can (2) calculate basic utility measures (absolute risk aversion, relative risk aversion, expected utility, certainty equivalent, risk premium); Students can also (3) explain and apply the basic models of portfolio theory, i.e. they can calculate the optimal portfolio allocation in the Markowitz mean-variance framework for an arbitrary set of asset returns under various constraints. Moreover, students (4) understand the fundamental concept of the Capital Asset Pricing Model and are able to (5) apply the model and its variants introduced in the module and also recognize the shortcomings of this model. Students (6) learn to use other asset pricing models and when to apply them. Finally, students (7) learn the theory, process and methods to measure the portfolios’ performance.

**Teaching and Learning Methods:**
The module combines various learning methods:
- Basic knowledge, theoretical concepts and practical examples will be provided through the lecture.
- Controversial discussions and active participation in class are encouraged to deepen understanding of the concepts presented.
- In the exercises, students will apply their theoretical knowledge to concrete
- Demonstration of how to apply portfolio optimization on real-world data by using Excel
- Students will get insights into practice via several guest lecture

**Media:**
Presentation slides, white board

**Reading List:**
Elton, E. J./ Gruber, M. J. (2006): Modern Portfolio Theory and Investment Analysis, USA, Wiley, 7th Edition.

Copeland, T. E./ Weston, J. F./ Shastri, K. (2006): Financial Theory and Corporate Policy, USA, Addison Wesley, 4th Edition.

**Responsible for Module:**
Kaserer, Christoph; Prof. Dr. rer. pol. habil.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Asset Management - Übung (WI000231, englisch) (Übung, 2 SWS)
Chen M

Asset Management (WI000231, englisch) (Vorlesung, 2 SWS)
Kaserer C, Chen M
For further information in this module, please click campus.tum.de or here.

## Module Description

### MGTHN0124: Advanced Seminar Operations and Technology: Research on the Finance and Operations Interface | Advanced Seminar Operations and Technology: Research on the Finance and Operations Interface

Version of module description: Gültig ab summerterm 2023

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

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

**Description of Examination Method:**
This module enables students to understand the financial and operational constraints faced by firms and how these two areas overlap in salient ways. Students with an operations background will be introduced to financing aspects in supply chains and operations, whereas students with a finance background will learn more about the operations implications of financing decisions. Students will have to deeply analyze several critical topics from traditional topics such as moral hazard or information asymmetry problems to novel research directions such as supply chain finance. Upon completion of this module, the students will be able to identify potential challenges by the firms or financial institutions. The students will also develop capabilities to establish the core problems and formulate the necessary objectives and constraints for setting an academic paper/thesis on the related topic. Moreover, by preparing the discussion for the module, the students will be able to enhance their skills to communicate complicated concepts and dynamics of the research in a comprehensive way.

The presentation on demonstrating one of the problems from the reading material accounts for 20% of the final grade (group grade). A seminar paper on deriving the solution to problems related to those learned throughout the seminar accounts for 80% of the final grade (individual grade). A detailed guide on content and deadline will be given at the beginning of the semester.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Desirable but not mandatory: Production and Logistics, Management Science

**Content:**
Subject-specific content
• Supply chain management
• Finance and Operations Interface

Methodological content (depending on assigned papers and limited to an introductory level)
• Game Theory
• Econometrics

**Intended Learning Outcomes:**
Upon completion of the module, students are able to
• understand the financial and operational constraints faced by firms and how these two areas overlap in salient ways,
• derive and prove given solutions in research studies,
• develop critical perspectives on operational problems and objectives setting with the understanding of how finance matters,
• generate practical insights from research studies,
• and be prepared for writing a master's thesis in the relevant field.

**Teaching and Learning Methods:**
Seminar
This module will be held hybrid to enable the participation of all students who are interested in this topic regardless of their physical location (i.e., there is no need to be present in Heilbronn). Further details will be shared after the final enrollment is confirmed.
Students will be provided with one main text on various topics related to the finance and operation interface. Additional research papers will be given for more specific cases of the theoretic concepts. Each week students will have to be prepared with a set of questions on the topic that would require a comprehensive and thorough understanding of the topic, for example, the dynamics of a model and deriving or proving the propositions. The lecturer will give a short review and facilitate the session while the main discussions will be done by the students to derive the solutions to the given set of questions.

**Media:**
Research papers and further material to be shared via Moodle, hybrid platform

**Reading List:**
Reading for main topics:

Babich, V., & Birge, J. R. (2020). Foundations and Trends at the Interface of Finance, Operations, and Risk Management. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.3693440

Examples of papers that we will discuss (this list is not meant to be comprehensive):

Babich, V., & Hilary, G. (2020). Distributed Ledgers and Operations: What Operations Management Researchers Should Know about Blockchain Technology. Manufacturing & Service Operations Management, 22, 223-240.

Babich, V., Marinesi, S., & Tsoukalas, G. (2020). Does crowdfunding benefit entrepreneurs and venture capital investors? Manufacturing & Service Operations Management, 23(2), 508-524.

Yang, S. A., Birge, J. R., & Parker, R. P. (2015). The supply chain effects of bankruptcy. Management Science, 61(10), 2320-2338.

**Responsible for Module:**
Wuttke, David; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Seminar Operations and Technology (MGTHN0124): Research on the Finance and Operations Interface (Seminar, 4 SWS)
Choi D, Wuttke D
For further information in this module, please click campus.tum.de or here.

# Module Description

## MGT001345: Advanced Seminar Economics, Policy & Econometrics: Food Governance, Fairness and Sustainability Scientific Writing and Exploratory Research Methods | Advanced Seminar Economics, Policy & Econometrics: Food Governance, Fairness and Sustainability Scientific Writing and Exploratory Research Methods

Version of module description: Gültig ab summerterm 2022

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

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

**Description of Examination Method:**
Grading will be based on a written report (consisting of a research protocol and related research findings) and an oral presentation (20 min) with subsequent discussion, both with an individual and a teamwork component. Both the written report and the oral presentation are worth 50% of the grade. The report and the oral presentation will demonstrate that students have gained in-depth knowledge on how to conceptualize, plan and conduct a research project. It will thus show that students are prepared to write their Master Thesis.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Knowledge in microeconomics

**Content:**
The module deals with issues of governance, fairness and sustainability in the food system.
Key topics of the module may thereby include:
- Locks-ins and levers for facilitating a transitions toward more sustainable food systems;
- Food labels (origin-based labels, animal welfare labels);
- Food quality standards;
- Potential paths for a transition to more sustainable food systems
- Private and public governance in food sectors
- Fairness in business relationships
- European and national regulations and policies concerning the food sector

From a methodological point of view, the focus of this module is on
- Exploratory and Qualitative research methods
- Scientific writing skills

**Intended Learning Outcomes:**
After successful completion of this module, students will have in-depth knowledge on how to conceptualize, plan and conduct a research project concerning good governance, fairness and sustainability in agro-food systems. Moreover, students will be able to i) identify and structure a research topic, ii) build a conceptual framework for qualitative research; iii) applying qualitative research methods to a concrete research question; iv) develop a study instrument; v) conduct interviews for qualitative research; draft a scientific research report. The module thereby prepares students for the scientific work to be conducted in their master theses.

**Teaching and Learning Methods:**
The module is a seminar and provides students with in-depth knowledge of governance, fairness and sustainability grounded in economic theory. The seminar includes a set of lectures on governance, fairness and sustainability.
Guided by the instructor(s) through the entire process, students will work alone and/or in groups around a topic in governance, fairness and/or sustainability.
Activities are carried out in parallel in coordination with foreign universities and students will have the opportunity to collaborate and exchange with students from those universities. The course takes place online.
Together with “Advanced Seminar Economics & Policy/Life Sciences & Management – Food system governance, fairness and sustainability, Literature Review and Presentation Skills”, this module offers a comprehensive toolkit to prepare students for their master thesis as well as for a career in science.

**Media:**
PowerPoint presentations, economic textbooks, scientific articles

**Reading List:**
Barathova, K., Cacchiarelli, L., Di Fonzo, A., Lai, M., Lee, H., Menapace, L., ... & Vandervelde, S. (2020). Pass-through of unfair trading practices in EU food supply chains: methodology and empirical application.
Bowie, N. E. (1988). Fair markets. Journal of Business Ethics, 7(1-2), 89-98.
Denzin Lincoln 2017 The SAGE Handbook of Qualitative Research
Gentile, E., Loi, A., Gentile, M., Bruni, M., Berisio, S., Parisi, P., ... & Rieger, L. (2020). Evaluation of Marketing Standards contained in the CMO Regulation, the “Breakfast Directives” and CMO secondary legislation. Final report.
James, H. S. (Ed.). (2013). The ethics and economics of agrifood competition (p. 99). Dordrecht, Netherlands: Springer.
Kvale 1996 Interviews: An Introduction to Qualitative Research Interviewing
Miles Huberman Saldaña 2014 Qualitative Data Analysis: A Methods Sourcebook

Russo et al. (2021) Upfront Costs as Coordination Devices in the European Agri-Food Value Chain, forthcoming.

**Responsible for Module:**
Menapace, Luisa; Prof. Ph.D.

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

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

## Module Description

# MGT001345: Advanced Seminar Life Sciences, Management & Policy: Food Governance, Fairness and Sustainability Scientific Writing and Exploratory Research Methods | Advanced Seminar Life Sciences, Management & Policy: Food Governance, Fairness and Sustainability Scientific Writing and Exploratory Research Methods

Version of module description: Gültig ab winterterm 2022/23

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

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

**Description of Examination Method:**
Grading will be based on a written report (consisting of a research protocol and related research findings) and an oral presentation (20 min) with subsequent discussion, both with an individual and a teamwork component. Both the written report and the oral presentation are worth 50% of the grade. The report and the oral presentation will demonstrate that students have gained in-depth knowledge on how to conceptualize, plan and conduct a research project. It will thus show that students are prepared to write their Master Thesis.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Knowledge in microeconomics

**Content:**
The module deals with issues of governance, fairness and sustainability in the food system.
Key topics of the module may thereby include:
-Locks-ins and levers for facilitating a transitions toward more sustainable food systems;
-Food labels (origin-based labels, animal welfare labels);
-Food quality standards;
-Potential paths for a transition to more sustainable food systems
-Private and public governance in food sectors
-Fairness in business relationships
-European and national regulations and policies concerning the food sector

From a methodological point of view, the focus of this module is on
-Exploratory and Qualitative research methods
-Scientific writing skills

**Intended Learning Outcomes:**
After successful completion of this module, students will have in-depth knowledge on how to conceptualize, plan and conduct a research project concerning good governance, fairness and sustainability in agro-food systems. Moreover, students will be able to i) identify and structure a research topic, ii) build a conceptual framework for qualitative research; iii) applying qualitative research methods to a concrete research question; iv) develop a study instrument; v) conduct interviews for qualitative research; draft a scientific research report. The module thereby prepares students for the scientific work to be conducted in their master theses.

**Teaching and Learning Methods:**
The module is a seminar and provides students with in-depth knowledge of governance, fairness and sustainability grounded in economic theory. The seminar includes a set of lectures on governance, fairness and sustainability.
Guided by the instructor(s) through the entire process, students will work alone and/or in groups around a topic in governance, fairness and/or sustainability.
Activities are carried out in parallel in coordination with foreign universities and students will have the opportunity to collaborate and exchange with students from those universities. The course takes place online.
Together with “Advanced Seminar Economics & Policy/Life Sciences & Management – Food system governance, fairness and sustainability, Literature Review and Presentation Skills”, this module offers a comprehensive toolkit to prepare students for their master thesis as well as for a career in science.

**Media:**
PowerPoint presentations, economic textbooks, scientific articles

**Reading List:**
Barathova, K., Cacchiarelli, L., Di Fonzo, A., Lai, M., Lee, H., Menapace, L., ... & Vandervelde, S. (2020). Pass-through of unfair trading practices in EU food supply chains: methodology and empirical application.
Bowie, N. E. (1988). Fair markets. Journal of Business Ethics, 7(1-2), 89-98.
Denzin Lincoln 2017 The SAGE Handbook of Qualitative Research
Gentile, E., Loi, A., Gentile, M., Bruni, M., Berisio, S., Parisi, P., ... & Rieger, L. (2020). Evaluation of Marketing Standards contained in the CMO Regulation, the “Breakfast Directives” and CMO secondary legislation. Final report.
James, H. S. (Ed.). (2013). The ethics and economics of agrifood competition (p. 99). Dordrecht, Netherlands: Springer.
Kvale 1996 Interviews: An Introduction to Qualitative Research Interviewing
Miles Huberman Saldaña 2014 Qualitative Data Analysis: A Methods Sourcebook

Russo et al. (2021) Upfront Costs as Coordination Devices in the European Agri-Food Value Chain, forthcoming.

**Responsible for Module:**
Menapace, Luisa; Prof. Ph.D.

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

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

# Module Description

## MGT001435: Impact Entrepreneurship for Transformational Change | Impact Entrepreneurship for Transformational Change

Version of module description: Gültig ab winterterm 2023/24

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>German/English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>9 | **Total Hours:**<br>270 | **Self-study Hours:**<br>190 | **Contact Hours:**<br>80 |

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

**Description of Examination Method:**
The examination consists of three components. In the accompanying online course, the content of the respective units is tested and deepened through reflection tasks and research tasks. This part represents 20% of the grade. Furthermore, the presentation prepared by the students at the end of the semester and its corresponding documentation (pitch deck or similar) is part of the examination (40%). A final report must also be submitted (also 40%).

As part of a final event, the teams present a solution idea for the problem they have chosen and developed in the area of society, ecology or technology. The presentation lasts 5-10 minutes. The students demonstrate that they are able to translate the information they have received into an independently developed impact-orientated business model and present this in an appropriate manner. They are supported in their preparation by regular feedback from lecturers and coaches.

The third part of the grade results from the final report. It documents in a structured way how the information received and the tools presented for working on an impact-orientated business model were implemented. Furthermore, the feedback received during the final presentation should be taken into account and incorporated. The report ensures that the students go beyond mere documentation of their results to structure and reflect on them. The final report should not exceed 7500 characters and must be submitted up to eight weeks after the end of the semester.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
- Basic understanding of entrepreneurship and its principles, such as from attending an introductory lecture on the topic, founding experience, or closely following the media on the topic
- Basic knowledge in sustainability

- Interest in developing innovative solutions from a systemic perspective to generate social and environmental impact

**Content:**
As part of the course, students from various disciplines spend a semester working intensively on social, ecological or technological challenges and the question of how these can be solved with the help of social and innovative business ideas.

The programme teaches methods and knowledge on topics such as system innovation, design thinking, future thinking, regenerative and impact-oriented business models, impact management and financing. The systemic perspective is of particular importance in the programme. In particular, the major social and ecological problems of our time cannot be solved in isolation as "wicked problems". Solutions are therefore only possible by viewing them as phenomena that are integrated into systems.

Students work in teams on social, ecological or technological challenges and apply the methodological knowledge they have acquired to develop an entrepreneurial solution for the selected problem. This process is structured and supported by lecturers and external coaches.

At the end of the semester, the students present the solutions they have developed in the form of impact-orientated business models. In this context, they receive feedback and the opportunity to apply for follow-up coaching for the business ideas they have developed. The final report reflects on the process they have gone through and structures the results.

The course is held in German in the summer semester and in English in the winter semester.

**Intended Learning Outcomes:**
The aim of the module is to enable students to develop practice-oriented solutions in the form of impact-oriented business models. The focus is on generating impact in the sense of the United Nations Sustainable Development Goals. Students will be able to

- explain the concept of impact and its implications and illustrate them using specific case studies.
- develop entrepreneurial solutions for real challenges in interdisciplinary teams.
- apply tools and methods from the fields of systems thinking, future thinking, human-centred design, impact orientation and business modelling to their challenges.
- present the solutions developed for their challenges using professional presentation techniques appropriate to the target group.
- categorise and discuss alternative economic models such as the Economy for the Common Good, Doughnut Economics and post-growth approaches.

The module focuses on experience-based and problem-oriented learning and aims to promote the development of social and entrepreneurial innovations as well as the promotion and development of students' skills with regard to responsible entrepreneurship. By developing solutions in interdisciplinary teams, students also improve their soft skills such as creativity, perseverance, communication skills, and interdisciplinary competences.

**Teaching and Learning Methods:**
Lectures and interactive, seminar-style teaching in the form of discussions, group work, development of challenges, team coaching sessions, feedback discussions, presentations, and Q&A sessions. The variety of methods ensures that the right method is chosen for each learning content to be taught. For example, new knowledge and tools are presented by experts in the field in keynote speeches and then discussed in large or small groups before being incorporated into the development of solutions. Feedback discussions and team coaching sessions facilitate the application of the tools and methods presented. The final presentation at the closing event gives participants the opportunity to practise their communication skills and improve them through appreciative, constructive feedback. The synchronous online and face-to-face teaching is supplemented by asynchronous elements of self-learning time via the accompanying online course and associated reflection tasks, as well as by self-organised project group meetings, which are documented in the final report.

**Media:**
Videos, presentations, online materials, quiz, exercise sheets, Power Point, flip charts, mural boards

**Reading List:**
Meadows, Donella: Thinking in Systems, Earthscan, 2009
Stroh, David Peter: Systems Thinking For Social Change: A Practical Guide to Solving Complex Problems, Chelsea Green Publishing, 2015
Kurz, B./ Kubek, D.: Social Impact Navigator, Phineo, 2017, verfügbar auf https://www.social-impact-navigator.org/

**Responsible for Module:**
Alexy, Oliver; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Impact Entrepreneurship for Transformational Change (MGT001435, deutsch) (Seminar, 4 SWS)
Alexy O [L], Alexy O ( Kaoui V, Vogel C )
For further information in this module, please click campus.tum.de or here.

## Module Description

### **MW2245: Think. Make. Start. | Think. Make. Start.** [TMS]

*Build innovative products of your ideas in 10 days!*

Version of module description: Gültig ab winterterm 2024/25

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

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

**Description of Examination Method:**
The module examination consists of a project work incl. written documentation (approx. 10 pages) and presentation (10 min), in which the students develop a new product in a group project and present their idea for founding a company on this basis. The individual performance is assessed to what extent the students are able to develop a product with market potential by means of an iterative approach to prototypical implementation. The assessment also includes the ability to work in a team, the ability to make well-founded design decisions and the completeness and conclusiveness of the concept, taking into account social relevance, novelty and innovation. As part of the project work, in addition to documentation, there is a final oral presentation. Through the presentation, students are expected to show whether they can demonstrate their ability to act as a competent team.

**Repeat Examination:**

**(Recommended) Prerequisites:**
The basic requirement is a willingness to engage with new learning methods, approaches, disciplines and ways of working. Cross-role experience in project management, product development (Design Thinking, TRIZ, Systems Engineering, etc), interdisciplinary teamwork, communication skills, creativity and problem solving skills are an advantage. A lot of emphasis is placed on practical experience.

For the "Problem Expert" role, experience in the following areas is an advantage:
- User Testing, Requirements Engineering, Interviewing, Human-Centered Design, Design, Visualisation, Use Case Definition, UX/UI Design, marketing, market research, benchmarking, design thinking.

For the "Tech Developer" role, experience in the following areas is an advantage:
- Hardware (mechanical): design, manufacturing (workshop/makerspace), prototyping, CAD/CAM.
- Hardware (electronic): embedded systems engineering, microcontrollers, sensors/actuators, Arduino, Raspberry, circuitry, board design, metrology, BUS protocols, prototyping, closed-loop/ open-loop control, robotics
- Software focus: Backend development, databases, frontend development, machine learning, web development, app development, embedded systems

For the "Business Developer" role, experience in the following areas is an advantage:
- Business Plan/Strategy/Design, Marketing, Sales, Interviewing, Finance & Accounting, Business Law & Regulations, Entrepreneurship.

The number of participants is limited and there will be an application process.

**Content:**
During the interdisciplinary team project, students work methodically, purposefully and agilely on a development project to develop innovative new products with the intention of successfully launching them on the market. Current needs and problems from social, technological and economic systems are identified, analysed and validated in the interdisciplinary team. In doing so, they cooperatively solve challenges that arise from constraints from the different disciplines. They generate suitable market hypotheses and product ideas at an early stage and interact with initial potential customers/users. They iteratively create prototypes and evaluate their hypotheses with them in experiments.

For more information, visit www.thinkmakestart.com and www.tms.tum.de.

**Intended Learning Outcomes:**
After participating in the module “Think.Make.Start.” the students are able to
- reproduce the principles of user-centered design
- apply methods of product development (e.g., Design Thinking) to a challenge of their choice
- develop important hypotheses involving relevant stakeholders (customer, user, ...) through proper planning with "purposeful prototyping"
- examine the relevance of a problem and develop a solution collaboratively in an interdisciplinary team
- design a prototype based on the acquired design methods and analyzed insights
- lay the foundation for one's own business start-up by identifying a start-up idea or team.

**Teaching and Learning Methods:**
"THINK. MAKE. START." is a two-week, practice-oriented, interdisciplinary and competitive teaching format in which students from all faculties can participate (credits are given individually related to the study program). It is organised by the different chairs of TUM, TUM ForTe, and UnternehmerTUM. They get access to the high-tech workshop Makerspace and budget to transform their own ideas into real prototypes (mechatronic products). Learning outcomes are achieved through the following teaching and learning methods:

- Milestones to be achieved, team roles to be held and predetermined course structure provide the roadmap for the project.
- Coaching and teaching expertise in prototyping, business validation, agile development, design thinking, systems engineering, lean startup and user-centred design.
- Teaching the basics of interdisciplinary collaboration through a role concept (Business Developer, Tech Developer, Problem Expert).
- All participants work in interdisciplinary teams (10 teams of 5 students each) and are encouraged to become active themselves and learn through practical experience (hands-on learning).
- Each team pursues a real business idea chosen for the seminar. Special attention is given to really understanding the customer and verifying the solution approach, through questioning, observation, prototyping or expert discussion.
- Using prototyping to bridge the gap between thinking and doing.
- Reflecting on one's own results and approach supports project decisions.
- The teams present their projects to a jury on DemoDay and present the prototypically implemented product ideas to guests from industry, the start-up scene and research.

**Media:**
Project manual, presentations, hand-outs, posters, videos, examples.

**Reading List:**
Esch Franz-Rudolf (2012) Strategie und Technik der Markenführung, 7. Auflage, Vahlen

Faltin, Günter (2008): Kopf schlägt Kapital, Hanser

Halgrimsson (2012): Prototyping and Model Making for Product Design (2012)

Kalweit Andreas, Paul Christof, Peters Sascha, Wallbaum Reiner (2012) Handbuch für Technisches
Produktdesign, Material und Fertigung, Entscheidungsgrundlage für Designer und Ingenieure, 2. Auflage, Springer

Kelly, Tom (2016): The Art of Innovation

Lindemann, U (2007): Methodische Entwicklung technischer Produkte - Methoden flexibel und situationsgerecht anwenden. 2. Auflage

Münchener Business Plan Wettbewerb: Handbuch Businessplan-Erstellung, München http://www.evobis.de/coaching/handbuch/

Malek, Miroslaw / Ibach, Peter K. (2004): Entrepreneurship, Dpunkt Verlag

Moore, Geoffrey A. (2002): Crossing the Chasm, Harpercollins

Osterwalder, Alexander / Pigneur, Yves (2010): Business Model Generation: A Handbook for

Ries, Eric (2011): The Lean Startup

Savoia, Antonio (2019): The right It

Timmons, Jeffry A. / Spinelli, Stephen (2009): New Venture Creation, 7thedition, McGraw, Hill Professional

UnternehmerTUM (2011): Handbuch Schlüsselkompetenzen, 7. Auflage

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

**Courses (Type of course, Weekly hours per semester), Instructor:**
Think.Make.Start. (Praktikum, 4 SWS)
Zimmermann M [L], Tong Y, Hohnbaum K, Amm M, Büchner B, Baur C, Bien S, Mogk J
For further information in this module, please click campus.tum.de or here.

## Module Description

### POL60803: Core Topic: Law and Digitization in Action (MSc. Politics & Technology) | Core Topic: Law and Digitization in Action (MSc. Politics & Technology)

Version of module description: Gültig ab summerterm 2020

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| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
Students are required to participate in exercises surrounding the meetings. Students have to participate in at least four exercises, three of which will count towards the final grade. Those exercises can be either small tasks like solving a legal problem question in written form or summarizing certain readings (regularly no more than 1000 words). In specific cases, this can also entail oral presentations.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
This module introduces students to the legal techniques of dealing with questions of science and digital technology. The seminar focuses particularly on emergent digital technologies such as artificial intelligence and the internet of things. By tackling one specific and recent topic concerning law, science and technology, the students deepen their knowledge  how the law can and does regulate specific situations. They also familiarize themselves with current regulatory debates concerning law and digitisation. Furthermore, they link their findings to general or specific concepts and constitutional principles such as the rule of law, human rights or transparency.

**Intended Learning Outcomes:**
Upon successful completion of this module, students are able to:
- categorize and understand major regulatory and design approaches concerning digital technologies.

- reflect on specific regulatory choices and their intended and unintended impacts.
- display and discuss a legal issue and develop and argue for one solution.
- reflect on the respective choices made in a legal argument and link it to important concepts of constitutional magnitude.
- engage in legal argument in class.

**Teaching and Learning Methods:**
Literature reviews help students to understand and categorize relevant major regulatory approaches and key legal concepts. In-class discussions, including mini moot courts (small argumentative exercises with preconceived roles) and case studies of specific artefacts, train students to display and discuss a legal issue, develop and argue for a solution and provide them with jurisprudential reflection skills. Online videos help them to prepare for classes.

**Media:**
Tba

**Reading List:**
Tba

**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.

## Module Description

### WIB101007: Advanced Topics in Finance & Accounting | Advanced Topics in Finance & Accounting

Version of module description: Gültig ab summerterm 2021

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| **Module Level:**<br>Master | **Language:**<br>German/English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>60 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
A performance record is acquired by a written exam (duration: 60 minutes). For the written exam approaches to digital transformation, current technological developments and processes for the digital transformation of business models will be relevant. Terminology will be checked in the exam with multiple choice questions and open questions, which will require students to apply their learning outcomes from the guest lectures. The presentation and discussion topics between students and speakers will be the basis for the examination questions. Students are only permitted to use a pen, ruler and protractor during the exam.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Advanced understanding of accounting and finance.

**Content:**
The chair of Managerial Accounting/Control, the chair of Financial Management and Capital Markets and the endowed chair in Entrepreneurial Finance offer different courses within this module. Topics of each individual course will be announced by the chairs. Further information will be available on the homepage of each chair.

Possible topics:
- Industrie 4.0
- Digitalization
- Transformation of business models
- Technology development
- Strategy development

- Process design
- Quality and IT-security
- Market development

**Intended Learning Outcomes:**
At the end of the module, students are able to identify and classify different approaches of digital transformation in different companies from large international corporations to medium sized enterprises in different sectors.
At the end of the module, students can evaluate successful business model transformations and compare them with other business model transformations.
At the end of the module, students are able to describe technological developments and asses their potential for the development of new business models.
At the end of the module, students can assess the market with regard to digital business models.
At the end of the module, students can design processes for the digital transformations of business models.

**Teaching and Learning Methods:**
The topics of the module are facilitated through lectures and presentations of guest lectureres from different industry branches.  Students are encouraged to study literature of recent topics and deal with problems of concrete examples in teamwork.

**Media:**
Lecture notes, presentation, case studies, discussion.

**Reading List:**
The literature of the module will be available on the website of the chair at the beginning of the semester (http://www.bwl.wi.tum.de).

**Responsible for Module:**
Wildemann, Horst; Prof. Dr. Dr. h.c. mult.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Topics in Finance & Accounting (WIB101007, deutsch): Perspektiven für Wachstum und Wandel (Vorlesung, 2 SWS)
Wildemann H [L], Helmts J, Jensch J, Müller F, Wildemann H
For further information in this module, please click campus.tum.de or here.

# Module Description

## WIHN0012: Digital Finance | Digital Finance [DF]

Version of module description: Gültig ab summerterm 2021

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

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

**Description of Examination Method:**
The module examination consists of a 90-minute written exam, in which the candidates should reproduce the knowledge imparted in the lectures. The students are also required to provide transfer knowledge. It is tested whether students have understood how Digital Finance relates to Traditional Finance and other financial research disciplices; which interdependencies exist among the research disciplines, etc. Dangers and Opportunities of FinTech applications should be understood in detail. Further, students are required to conduct and assess mathematical calculations. The written exam also comprises open questions as well as multiple-choice-tasks.

In addition, by participating in group work studies with presentation on a specific Digital Finance Topic (case study), students have the option to enhance their final grade by up to 0,3. The group studies aim at ensuring a continuous process of learning.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge of corporate finance/financial mathematics is required (e.g. material covered in the course Corporate Finance); joint election with the module "Advanced Seminar in Finance/Accounting: Current Research Topics in Digital Finance" highly recommended

**Content:**
The aim of the course is to give a comprehensive overview on Digital Finance, not covered elsewhere in courses of Corporate Finance within the Master in Management. It provides a coverage of the most recent relevant topics in the field of Digital Finance. Basic knowledge in the field of financial mathematics is a pre-requisite.

The module comprises the most important and most recent developments in Digital Finance. Specifically, it comprises (but is not limited to) the following areas:

- History of Digital Finance and how it relates to other financial research disciplines;
- Robo-Advisors;
- Crowd Funding;
- Peer-2-Peer-Lending;
- Social Media in Finance;
- Digital Payments;
- Cryptocurrencies;
- Digital Technologies (Big Data and Machine Learning; Textual Analysis; Blockchain)
- Cybersecurity;
- Digital Finance and the Market Efficiency Debate;
- The Future of Digital Finance;
- Regulation;
- etc.

**Intended Learning Outcomes:**
The students acquire detailed knowledge on how technological innovations are changing existing financial services and products, their implications and possible applications within the financial industry. Specifically, upon completion of the module, students will be able to identify changes and opportunities of Digital Finance and its implications for the overall macroeconomic stability.

Also, students will be able to fully understand limitations of the digital transformation within the financial industry and its underlying causes. Finally, the students will be able to assess how and why digital finance applications influence the market (in-)efficiency of existing financial markets. In particular, the students are able to analyze complex financial market relations while taking into consideration various influencing factors (as for instance irrational investor behavior).

**Teaching and Learning Methods:**
Types of instruction comprise lecture courses as well as practical courses;

Methods of teaching include lectures, presentations as well as guest lectures;

the learning methods of the students primarily comprise the following activities:
- Follow-up of course contents;
- Exercise and execution of financial calculations;
- Preparation and executation of presentations;
- Ability to answer advanced thematic issues;
- etc.

The chosen types of instruction / methods of teaching are considered adequate to foster/extend the students' ability to fully understand and elaboratethe in-depth the thematic content.

**Media:**
Lecture slides; whiteboard; exercise sheets; exercise portfolio; flipchart; powerpoint; films

**Reading List:**
Due to the topicality of this lecture, the usage of reference books is only in a limited manner possible. Still, the below-listed references are considered as a solid starting point for the contents of this lecture.

Goldstein, I., Jiang, W., & Karolyi, G. A. (2019). To FinTech and Beyond. The Review of Financial Studies, 32(5), 1647-1661.

Blakstad, S., & Allen, R. (2018). FinTech Revolution: Universal Inclusion in the New Financial Ecosystem. Palgrave Macmillan.

Chuen, D. L. K., & Deng, R. H. (2017). Handbook of blockchain, digital finance, and inclusion: Cryptocurrency, FinTech, InsurTech, regulation, ChinaTech, mobile security, and distributed ledger. Academic Press.

Dorfleitner, G., Hornuf, L., Schmitt, M., & Weber, M. (2017). FinTech in Germany. Cham: Springer International Publishing.

Fatas, A. (Ed.; 2019). The Economics of Fintech and Digital Currencies. CEPR Press.

Scardovi, C. (2017). Digital transformation in financial services. Springer.

**Responsible for Module:**
Müller, Sebastian; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Digital Finance (WIHN0012) (Vorlesung mit integrierten Übungen, 4 SWS)
Breitung C, Müller S
For further information in this module, please click campus.tum.de or here.

# Module Description

## WIHN0018: Economics and Management of Platforms | Economics and Management of Platforms

Version of module description: Gültig ab winterterm 2019/20

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

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

**Description of Examination Method:**
Seminar paper with presentation: Each student will be assigned a reader of research papers, book chapters, and case studies to work on. To pass the course, students have to write a seminar paper and present the seminar paper in class.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
very strongly recommend you previously attend an introductory course on economics (e.g., “Principles of Economics”) and management (e.g., “International Management”). Also, the attendance of a course on empirical research methods (e.g., "Empirical Research Methods in Management and Economics") is recommended.

**Content:**
Digital platforms (e.g., Uber, iOS, AirBnB) are transforming entire industries. The drivers of platform markets’ success are complex, and the successful setup and management of a platform requires a sound theoretical understanding of the concepts of network effects, two-sided markets, and complementarity.

The seminar seeks to provide an advanced understanding of the following questions:

- What are digital platforms and how do they impact markets?
- Which economic principles underlie platforms?
- What strategies enable firms to successfully establish platforms?

**Intended Learning Outcomes:**
Knowledge Objectives
After the course, students will be able to:
- Understand the concept of digital platforms from a managerial and economic perspective
- Understand the economic impact of platforms
- Outline the economic principles underlying platforms
- Craft and evaluate strategies for the effective management of digital platforms

Skills Objectives
- Improve diagnostic and analytical skills (i.e., structured problem-solving)
- Build up critical thinking and interpretation skills
- Enhance verbal and argumentation skills via presentations and group discussions

**Teaching and Learning Methods:**
The introductory session will provide an introduction into the key concepts and academic writing in a lecture-style. The largest share of this course will be based on interactive discussions among course participants and based on the presentations of the course participants. A large share of learning will occur through you preparing for the in-class session.

**Media:**

**Reading List:**
- Shapiro, Carl, and Hal R. Varian. Information rules: a strategic guide to the network economy. Harvard Business Press, 1998.
- Parker, Geoffrey G., Marshall W. Van Alstyne, and Sangeet Paul Choudary. Platform revolution: how networked markets are transforming the economyand how to make them work for you. WW Norton & Company, 2016.

**Responsible for Module:**
Förderer, Jens; Prof. Dr. rer. pol.

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

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

## Module Description

### WIHN0020: Empirical Research Project in Finance | Empirical Research Project in Finance

Version of module description: Gültig ab summerterm 2024

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
The examination comprises a scientific group-based coursework (approx. 30 pages) about a research project, which is supposed to be conducted together with and under the guidance of the lecturer.  In exceptional cases and after consultation, it is also possible to carry out the research project alone in certain cases. The coursework should comprehensively document the research project (research question, literature contribution, data elicitation and data preparation, data analysis, results and interpretation, further research questions). Additional to the written scientific report, candidates are required to showcase main findings within a 30-minute presentation and answer further questions following their presentation.

In doing so, it can be assessed to what extent the students have been able to successfully conduct the research project

The written assigment will be weighted 80% and the formal presentation will make 20% of the final grade. The assessment is based on the groupwork (no indivudual assessment).

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge in corporate finance;
basic knowledge in scientific writing;
motivation letter

**Content:**
The research project is in the field of empirical capital market research and will be announced at the beginning of each semester. The project will be developed and implemented in joint meetings and  on the basis of independent (group-)work.

Candidates are expected to conduct a comprehensive literature review of the most important scientific articles related to the research topic in order to address the given research questions in a systematic and structured manner. It is further expected that candidates learn how to work with capital market databases and mathematical-statistical software packages and learn how to apply appropriate analysis methods.

This modules requires an intensive supervision by and collaboration with the lectures. The maximum number of course participants is therefore set to three. Candidates are chosen on the basis of their motivation letter.

**Intended Learning Outcomes:**
Upon completion of the module, students will be able to …

- conduct an independent literature analysis at the highest possible, international level;
- work with different capital market databases;
- work with different mathematical-statistical software packages and other tools;
- conduct an empirical research project alone and in a research team;
- deriver answers to posed research questions in a systematic and structured manner;
- create/draft a scientific report independently

**Teaching and Learning Methods:**
Types of instruction comprise regular meetings with the lecturer about the current status of the research project and further steps as well as the corresponding main seminar;

Methods of teaching comprise a group-based coursework and the formal presentation of obtained results;

the learning methods of the students primarily comprise the following activities:
- Independent literature research (usage of scientific articles published in international top journals);
- Collaborative Implementation of the research project (research question, literature contribution, data elicitation and data preparation, data analysis, results and interpretation, further research questions);
- Collaborative writing of a scientifc report;
- Exercise of a deductive, logic and consistant argumenation to specifically address and answer the posed research questions;
- Preparation and executation of a final presentation;
- Ability to answer advanced thematic issues

The chosen types of instruction / methods of teaching are considered adequate to foster/extend the students' ability to conduct independent academic work and to elaborate thematically complex contents on their own. It is considered to be a good preparation for the students' master theses.

**Media:**
Exercise sheets, PowerPoint

**Reading List:**

A separate reading list for the research topic will be provided at the beginning of the semester.
To familiarize with the basic software packages and econometric methods the following literature might be useful:

Angrist, J., Pischke, J.-S. (2009). Mostly Harmless Econometrics: An Empiricist's Companion. Princeton University Press.

Gujarati, D., Porter, D., Gunasekar, S. (2009). Basic Econometrics.  McGraw-Hill/Irwin.

Kohler, U., Kreuter, F. (2012). Data Analysis Using Stata. Stata Press.

Müller, A., Guido, S. (2016). Introduction to Machine Learning with Python: A Guide for Data Scientists. O'Reilly.

**Responsible for Module:**
Müller, Sebastian; Prof. Dr. rer. pol.

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

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

## Module Description

# WIHN0024: Advanced Seminar Finance & Accounting: Current Research Topics in Empirical Capital Market Research | Advanced Seminar Finance & Accounting: Current Research Topics in Empirical Capital Market Research

Version of module description: Gültig ab winterterm 2019/20

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>165 | **Contact Hours:**<br>15 |

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

**Description of Examination Method:**
The examination comprises a scientific coursework (approx. 20 pages), which is supposed to address the research questions posed within each given seminar topic. The task is to be conducted alone or as a group work (i.e. 2-3 students per topic). It will be communicated in the introductory session if individual work or group work is required (depending on class size). Additional to the written scientific report, candidates are required to showcase main findings within a 30-minute presentation and answer further questions following their presentation.

To maintain the seminar atmosphere, the number of participants is generally limited. If the course is offered in a hybrid format, Munich students may also participate in the course. More information will be provided in the introductory session.

In doing so, the candidates are required to prove that they have dealt with the given topic in a comprehensive manner, that their selection and evaluation of literature is adequate and that they have in-depth analyzed the topic while simultaneously putting it in a higher context of financial research. Also, it can be assessed whether the students are able to answer further questions in a correct and comprehensive manner.

The written assignment will be weighted 2/3 and the formal presentation will make 1/3 of the final grade. Each student will be assessed separately.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge in corporate finance;
basic knowledge in scientific writing

**Content:**
Candidates are supposed to choose one seminar topic out of a set of pre-defined scientific issues. Those topics will be published on Moodle in advance and will be presented in detail during the introduction session.

Candidates are expected to conduct a comprehensive literature review of the most important scientific articles capturing the chosen seminar topic in order to address the given research questions in a systematic and structured manner.

**Intended Learning Outcomes:**
Upon completion of the module, students will be able to …

- exhibit a comprehensive overview on current research topics in the field of Empirical Capital Market Research;
- identify chances and opportunities of these developments (especially with regard to the overall macroeconomic stability);
- conduct an independent literature analysis at the highest possible, international level;
- analyze and evaluate references in a systematic manner;
- combine current topics in Empirical Capital Market Research with theories/methods/models of traditional finance in an independent manner;
- derive answers to posed research questions in a systematic and structured manner;
- create/draft a scientific report independently

**Teaching and Learning Methods:**
Types of instruction comprise an initial lecture (overview course) as well as the corresponding main seminar;

Methods of teaching include an individual work or group work and the formal presentation of obtained results;

the learning methods of the students primarily comprise the following activities:
- independent literature research (usage of scientific articles published in international top journals);
- Collaborative writing of a scientifc report;
- Exercise of a deductive, logic and consistant argumenation to specifically address and answer the posed research questions;
- Preparation and executation of a final presentation;
- Ability to answer advanced thematic issues

The chosen types of instruction / methods of teaching are considered adequate to foster/extend the students' ability to conduct independent academic work and to elaborate thematically complex contents on their own. It is considered to be a good preparation for the students' master theses.

**Media:**
Exercise sheets, PowerPoint

**Reading List:**
Berk/deMarzo (2013): Corporate Finance, 3rd ed., Pearson

A separate reading list for each topic will be provided in the introductory lecture.

**Responsible for Module:**
Müller, Sebastian; Prof. Dr. rer. pol.

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

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

## Module Description

### WIHN0049: Economic Analysis of Contracts, Competition and Companies | Economic Analysis of Contracts, Competition and Companies

Version of module description: Gültig ab winterterm 2020/21

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

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

**Description of Examination Method:**
The examination includes an oral report where the students will present and discuss their work for the seminar paper (30% of the grade). Moreover, students will prepare a seminar paper. In order to support students in writing process, there will be regular discussions about the progression of the project (seminar paper and regular discussions = 50% of the grade). On top of that, students' participation in the classes' discussions of cases will be evaluated (20% of the grade). The active participation in the case discussions measures the students' ability to use the theoretical knowledge of the seminar to analyze real complex situations. The written examination and the corresponding presentation are means to evaluate the student’s ability to work with a case, incorporate legal and economic concepts and present a sound study that incorporates the seminar's topics. In the oral report, students also show that they can summarize, academically present, and discuss the subject. Finally, regular discussions with the instructor measure the student's ability to develop an idea, shape it and elaborate a structured project within a given timeframe.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
None

**Content:**
Market structures (perfect competition, monopoly, oligopoly, monopolistic competition)
Anti-competitive practices: horizontal and vertical restraints (dumping, price fixing, cartels, etc.)
European regulation and cases.
Economic criteria to analyze situations related to these topics in business environments.

**Intended Learning Outcomes:**
Students get to know different market structures and their regulation. They acquire elements to analyze and discuss how those structures and the legal mechanisms affect consumers and firms. Participants will gain a basic understanding of contractual structures that are relevant for the economic analysis of the legal framework. Finally, students will learn how to combine their knowledge about topics with the discussion of cases, integrating praxis elements into their analysis. Thus, they can evaluate whether practices in this area are legal and/or economically sensible according to context information.
Argumentative and analytical competencies are strengthened since cases are always open for debate. Their ability to propose creative solutions and work in a team will also be exercised continuously in their work cases.

**Teaching and Learning Methods:**
This seminar presents concepts and tools to analyze competition practices and market structures from a legal and an economic point of view. The seminar integrates a case study with the topics, so students have the opportunity to apply their learnings and implement them in their analysis. Students will study a specific case, expose their understanding, and analyze the case using legal and regulatory elements and economic criteria. Finally, students will present their work in class.

**Media:**
Case studies,exercises, PPT, Whiteboard

**Reading List:**
Mankiw, Principles of Economics (2014); Kovac/Vandenberghe, Economic evidence in EU Competition Law (2018); Posner, Economic Analysis of Law (2014)

**Responsible for Module:**
Jung, Stefanie; Prof. Dr. jur.

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

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

# Module Description

## WI001228: Economics of Environmental and Climate Policy | Economics of Environmental and Climate Policy

Version of module description: Gültig ab winterterm 2019/20

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>150 | **Self-study Hours:**<br>0 | **Contact Hours:**<br>150 |

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

**Description of Examination Method:**
The performance of course participants is examined in form of a written exam (90 minutes) at the end of the semester. Closed, half-open and open-ended questions are used to test whether the students can economically analyze environmental and climate policy measures and explain the environmental policy practice using the New Political Economy. Answering the questions requires own formulations.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
BSc.

**Content:**
Evaluation criteria for environmental and climate policy measures based on welfare economics are used to derive a normatively optimal policy with regard to equity and temporal dimensions. We present economic cost-benefit analysis as a tool for the economic evaluation of environmental and climate protection measures. Subsequently, the suitability of environmental policy measures to overcome specific environmental problems is discussed. We compare a command and control approach with pollution taxes, pollution abatement subsidies and emissions trading. In addition to questions of allocation, the importance of transaction costs and technical progress is discussed. Against the background of environmental risks, the importance of property rights and liability rules is explained. An introduction to the public choice theory is given to explain the implementation of policy measures in practise. We discuss voter models for the analysis of political competition, decision-making rules and voting procedures, as well as the political influence of interest groups and bureaucracy. Against the background of global environmental and climate protection problems, game-theoretical explanations are presented.

**Intended Learning Outcomes:**
In this course, policy measures for environmental and climate protection will be analysed theoretically based on welfare economic approaches whereas the implementation in practice will be discussed based on the public choice theory. The course attendees get to know valuation criteria for environmental and climate policy measures, which take into account temporal dimensions, risk considerations and aspects of equity. After successfully attending the module, the students are able to understand the effects of specific economic policy measures and to evaluate them in terms of welfare economics. With regard to the practical design of environmental and climate policy, the students acquire a comprehensive understanding of how political behaviour, collective decision-making processes and structures can be explained by using public choice theory. Attending the module enables the participants to analyse the individual and collective actions of political actors such as voters, administrations, parties and interest groups, as well as to apply game-theoretical explanations for international negotiations in the context of climate and global environmental problems.

**Teaching and Learning Methods:**
The module consists of lectures. A lecture is a suitable form of imparting the theoretical foundations of environmental and climate policy analysis. The lecturer explains the relevant content; questions from the students can be clarified during the lecture. This ensures that all students get an in-depth insight into the topics at the same level. The students are also encouraged to study the relevant literature.

**Media:**
Slides, Moodle

**Reading List:**
Fees, E (1998): Umweltökonomie und Umweltpolitik.
Beckenbach et al. (2009): Diskurs Klimapolitik.
Tietenberg, T. and L. Lewis (2010): Environmental Economics and Policy.
Kirchgässner (2002): Demokratische Wirtschaftspolitik
Martiensen, J. (2000): Institutionenökonomie.
Weimann J. (1996): Wirtschaftspolitik.

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

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

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

# Module Description

## WI001239: Master Thesis Research Seminar | Master Thesis Research Seminar

Version of module description: Gültig ab summerterm 2020

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>60 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
The examination consists of a case study / academic elaboration, including a research paper (grade contribution 60%) and in-class presentation (grade contribution 40%). The paper will reveal students' understanding of the necessary theoretical material, methods to perform empirical analysis, and their ability to apply those to analyze real-world situations.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Microeconomics 1

**Content:**
The seminars  will review and discuss the concepts of supply chain, decision making under uncertainty, externalities, domestic and international competitiveness, energy transition, carbon neutrality, e-mobility, smart city

**Intended Learning Outcomes:**
Upon successful completion of the course, students will be equipped to perform research needed to complete their master thesis requirements

**Teaching and Learning Methods:**
Presentation of scientific material; in-class discussions of developments and challenges in the automobile industry, analysis and excersices exploring industry related data. Besides simulating company-like environment when students have to identify and solve management and strategic

development problems, the class would teach students to organize their thinking in formal terms and see broad implications of their analysis.

**Media:**

**Reading List:**

**Responsible for Module:**
Ikonnikova, Svetlana; Prof. Ph.D.

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

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

## Module Description

# WI001264: Advanced Seminar Economics, Policy & Econometrics: Decisions under Uncertainty from Description and from Experience | Advanced Seminar Economics, Policy & Econometrics: Decisions under Uncertainty from Description and from Experience

Version of module description: Gültig ab winterterm 2020/21

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

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

**Description of Examination Method:**
Participants will work in small groups.
The formal requirements of this seminar consist of a. giving a presentation in front of their classmates and b. writing a seminar thesis.
For the presentation, participants will select a paper from a range of topics that will be discussed in the introductory lecture.
Participants are expected to be able to identify the key points of this paper as well as to communicate and to defend those points in front of a broader audience in an efficient and succinct way.
For the seminar thesis, participants will build on the paper/topic they selected for their presentation by exploring how the insights from the "Decisions from Experience" paradigm can be applied to the paper's core thesis. In doing so, they are expected to conduct a literature review, propose a research question and develop a study-design through which this question can be empirically tested.
The final grade will be based on the written seminar thesis (70%), but the group presentation of a research topic will allow students to improve their final grade (30%).

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basic understanding of mathematical and statistical principles. Familiarity with microeconomics will be helpful, though not essential.

**Content:**
People very often make decisions under uncertainty regarding future consequences of their actions and their likelihood. Models in Economics often assume that people have full access to numerical descriptions of such uncertainty. In reality, however, people often inform their decisions from past experience. Recently, research in behavioral economics has demonstrated that the two forms of information: from description and from experience, can lead to very different types of decisions. This seminar provides an overview of the standard methods that Economists use to study decisions involving risk as well as the latest insights and methodology for studying such decision when information is obtained from experience. Participants will work in groups in order to prepare a presentation related to the selected topic as well as to develop a paper thesis where they implement the tools and concepts of decisions from experience in order to augment and/or rexamine the finding in the current literature of the selected topic. Each group will select one of the following, broadly defined, topics:
a. Investment decisions b. Tax evasion, cooperation and punishment c. Medical decision making d. Consumer behavior
The seminar will equip participants with tools that are commonly applied in Behavioral Economics, such as theoretical modelling and the key principles of experimental methods.

**Intended Learning Outcomes:**
This seminar aims to 1) equip participants with the state of the art concepts of decisionmaking under risk or uncertainty 2) learn important methodological tools from Behavioural and Experimental Economics 3) develop their presentation skills by communicating the most important insights from their selected topic to their classmates. Moreover, paricipants 4) will practice their ability of conducting literature reviews and deriving important research gaps to their topic and summarize both main insights and research gaps. Finally, 5) participants will exercise their ability to think critically by coming up with an idea to further research in the specified area by enriching standard Economics principles with state of the art insights from Psychology.

**Teaching and Learning Methods:**
This module is a seminar. The introductory meeting will discuss the subtopics, and highlight some seminal findings in the area. In the first phase participants will concentrate on learning by reading relevant scientific literature, presenting one topic per group and discussing questions and interlinkages to related topics. In the second phase, students will produce a written paper in which they need to show their understanding of the respective topic, their capability to identify research gaps in the discussed literature as well as their critical thinking in discussing how an established line of research in Economics - related to the topic the group has selected - can be adjusted through the insights of the decisions from experience program.

**Media:**
Slides, Videos, Zoom-meeting, academic papers.

**Reading List:**
Indicative academic literature (further suggestions based on specific topics will be provided at the beginning of the seminar):

Hertwig, Ralph, et al. "Decisions from experience and the effect of rare events in risky choice." Psychological science 15.8 (2004): 534-539.

Hertwig, Ralph. "The psychology and rationality of decisions from experience." Synthese 187.1 (2012): 269-292.

Thaler, Richard H. "Behavioral economics: Past, present, and future." American Economic Review 106.7 (2016): 1577-1600.

Kahneman, Daniel, and Amos Tversky. "Prospect theory: An analysis of decision under risk." Handbook of the fundamentals of financial decision making: Part I. 2013. 99-127.

Simon, Herbert A. "The sciences of the artificial, 1969." Massachusetts Institute of Technology (1981).

**Responsible for Module:**
Goerg, Sebastian; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Seminar Economics, Policy & Econometrics (WI001264, englisch): Decisions under Uncertainty from Description and from Experience (Limited places) (Seminar, 4 SWS)
Kopsacheilis O
For further information in this module, please click campus.tum.de or here.

## Module Description

### WI001281: The Economics of Firm Competition | The Economics of Firm Competition [EconFirms]

Version of module description: Gültig ab winterterm 2020/21

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

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

**Description of Examination Method:**
A written examination is deemed appropriate to test the ability of students to analyse static and dynamic strategic behaviour of firms. Specifically, it assesses whether students can explain the role of competition, market power and coordination in markets. Students have to prove that they understand and can analyze the impact of firm behavior and industry structure on welfare and evaluate the welfare effects of competition policy. Students will be permitted to use non-programmable calculators during the examination. The exam duration is 90 minutes.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Undergraduate class work in microeconomics or industrial organisation.

**Content:**
The course provides an overview about firm behaviour. Topics discussed include:
• Competition and market power in markets
• The structure of industries and markets
• Strategic interactions among firms
• Vertical relations and coordination in markets
• The effect of firm behaviour on industry efficiency and societal welfare

**Intended Learning Outcomes:**
After successfully completing the module, students will be able:
• To describe the various forms of market structure;
• To explain the role of competition, market power and coordination in markets;
• To apply analytical tools to analyse strategic firm behaviour and interactions;

• To understand the impact of firm behaviour and industry structure on welfare and competition policy.
• To explain coordination and the conditions for efficient coordination.

**Teaching and Learning Methods:**
Application of various teaching methods to optimize structure and rhythm:
• Lecture
• Interactive methods
• Experiments in the lecture
• Discussion of relevant literature
• Exercises

**Media:**

**Reading List:**
Recommended textbook
- J. Church and R. Ware, Industrial Organization: A Strategic Approach, first edition, McGraw-Hill, 2000. (available for free online)

Other suggestions:
1. Jean Tirole: Industrial Organization.
2. Belleflamme and Peitz: Industrial Organization: Markets and Strategies.
3. Motta: Competition Policy: Theory and Practice

**Responsible for Module:**
Menapace, Luisa; Prof. Ph.D.

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

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

## CS_Unternehmer: UnternehmerTUM (max. 6 ECTS) | UnternehmerTUM (max. 6 ECTS)

## Module Description

## WI000285: Innovative Entrepreneurs - Leadership of High-Tech Companies | Innovative Entrepreneurs - Leadership of High-Tech Companies

Version of module description: Gültig ab summerterm 2021

| | | | |
|---|---|---|---|
| **Module Level:**<br>Bachelor | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>60 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
The examination performance is achieved through individual project work, which is divided into three phases. In the first phase, the students intensely engage themselves over a period of six to eight weeks with a self-chosen "Inner Development Challenge" from one of the following topic areas: Relationship to Self, Cognitive Skills, Caring for Others and the World, Social Skills, and Driving Change. Subsequently, in the reflection phase, a written reflection paper is produced in which the students critically reflect on their experiences and draw conclusions for their future.
In the Peer feedback phase, the students read and analyze five reflection papers of their fellow students. This fosters the students' ability to critically analyze their own works as well as the works of others and to give and receive effective feedback.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
- Knowledge: No special requirements, willingness to participate
- Abilities: Identifying opportunities; proactiveness; communication; commitment
- Skills: openness; analytical thinking; visual thinking; self-motivation; networking

**Content:**
The objective of the module is to inspire and motivate the participants coming from various disciplines for an entrepreneurial career, and to give them a basic understanding about founding

and managing technology- and growth-oriented companies. To serve this purpose, the module provides an introduction to the topic of (effectual) entrepreneurship, as well as guest lectures by outstanding founders, entrepreneurs, managers, and investors on selected topics, such as:

1. The entrepreneurial ecosystem
2. Founding of companies for students and scientists
3. How to develop an idea into a market-ready product
4. Financing of startups
5. Corporate growth
6. Creating and managing an entrepreneurial culture
7. Strategic business management
8. Innovation management
9. Corporate finance
10. Business succession

Moreover, for self-motivated participants, there is ample opportunity for personal development through interactive workshops, closed networking events.

**Intended Learning Outcomes:**
Upon successful completion of this module, participants will be able to...
- understand the entrepreneurial mindset
- recognize and develop personal strengths
- develop and implement personal ideas
- understand Design Thinking methodology

Moreover through guest speakers' lectures and optional workshops participants will be empowered to:
- realize opportunities and challenges associated with the founding and managing of technology- and growth-oriented companies;
- create a personal roadmap for entrepreneurial success.

Thus, students familiarize with topics like opportunity recognition, innovation management, growth, leadership, and the facets of entrepreneurship. In doing that, they are enabled to see, realize, and experience the multiplicity in the everyday life of an entrepreneur, entrepreneurial personalities, as well as entrepreneurial skills and motivations.

**Teaching and Learning Methods:**
As guest lecturers, each week an outstanding founder, entrepreneur, manager, or investor, spanning a wide-ranging industrial spectrum, is hosted to report on their individual entrepreneurial careers.

At the end of each lecture, the participants can actively engage in discussions with the guest speaker during an open session.

Moreover, in context of a workshop, the participants venture their own personal qualities and skills to understand in a structured way their own entrepreneurial identity. In doing that, they focus on their individual strengths and resources to develop a plan to be entrepreneurial.

The module also provides participants with ample opportunity to network with people from the entrepreneurial environment of TUM.

**Media:**
- Lecture slides downloadable
- Online discussion forum (e.g., for questions and feedback on guest lectures)
- Handouts (distributed online)

**Reading List:**
Read, S., S arasvathy, S., Dew, N., Wiltbank, R., & Ohlsson, A. V. (2016). Effectual Entrepreneurship. Taylor & Francis

**Responsible for Module:**
Schönenberger, Helmut; Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Innovative Entrepreneurs - Leadership of High-Tech Companies (WI000285, englisch) (Vorlesung, 2 SWS)
Schönenberger H [L], Schönenberger H, Schuster C
For further information in this module, please click campus.tum.de or here.

## Module Description

# MGT000159: Business Plan - Basic Course (Business Idea and Market) | Business Plan - Basic Course (Business Idea and Market)

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
The examination consists of the preparation of a semester-long project work (business idea) as a team. It consists of the written preparation of a business plan (7-10 pages in length, with specified topic contributions per team member, accounting for 30% of the assessment) and a final presentation (duration: 8 minutes pitch and 8 minutes Q&A, with equaly distributed presentation parts per team member, accounting for 70% of the assessment). The presentation contains, among other things, the most important learnings from the customer interviews and the demonstration of an interactive prototype of the developed product or service.

The project work assesses the extent to which students can identify and implement business opportunities. The business plan presents in a precise and structured way how well the participants have analyzed and understood the needs of their customer. The business plan also examines whether students are able to identify markets for their business idea and analyze market entry opportunities and market positioning. The preparation of initial sales and cost estimates shows whether the students are able to develop a viable business model. In the final presentation, each participant must explain their understanding of this content and defend it in front of the expert jury.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
- Knowledge: No special requirements, willingness to participate
- Abilities: Identifying opportunities; team work; communication; commitment; reliability - Skills: openness; analytical thinking; visual thinking; self-motivation

**Content:**
In iterative, feedback-driven steps, participants learn to think through and present a business idea for solving a customer problem in a structured manner in the form of a business plan. The basic chapters of a business plan listed below are developed for this purpose. The participants network with people from the start-up environment at TUM.

- Brief description of the business idea in the executive summary
- Detailed description of the understanding of the problem, including insights gained from interviews into the needs structure of paying customers and non-paying users
- Detailed description of the developed solution, including documentation of the prototype implementation and substantiation with feedback gained from customers and users
- Comprehensive analysis of the respective market, entry opportunities, competitive analysis and positioning in the market
- Development of a business model suitable for the business idea, including initial sales and cost estimates as well as approaches for successful legal protection

**Intended Learning Outcomes:**
After participating in the module, students are able to
- Identify a real customer problem through feedback, field studies and contextual observations and create a customer benefit with the proposed solution idea
- Recognize opportunities and present prototypical business concepts, e.g. with the help of a business plan
- Evaluate ideas and recognize business opportunities
- Segment markets and identify and characterize potential niche markets
- Develop a business model that includes a clear positioning in the market and a clear differentiation from competitors
- Present their business idea convincingly and based on market data
- Demonstrate the product or service using an interactive prototype

**Teaching and Learning Methods:**
Seminar style: The lecturers are entrepreneurs, serial founders, coaches and former managing directors.
- Interdisciplinarity: Participants form cross-study teams to ensure a target-oriented mix of expertise and skills in the team.
- Action Based Learning: All participants are encouraged to take action and learn through experience and an iterative approach.
- Learning-by-doing: Each team pursues a real business idea or a business idea chosen for the seminar (no case study). Particular attention is paid to really understanding the customer, for example through interviews, observation or expert discussions.
- Prototyping: The teams use interactive prototypes to develop their business idea and make it tangible.
- Online networking: The work in the seminar is accompanied by online tools such as Google Classroom, Slack and Zoom to support the work in the team.

- Peer-to-peer pitching: Each team pitches its idea briefly and succinctly to other teams on the course and receives feedback from them. In this way, the teams get to know different business models and business design approaches.
- Presentation training: Each team presents its business idea several times and receives verbal feedback on presentation style and content.

**Media:**
- Videos
- Slides
- Handouts via the Learning Management System
- Slack as a communication solution for efficient teamwork

**Reading List:**
- Horowitz, Ben (2014): The Hard thing About Hard Things, HarperBusiness
- Kawasaki, Guy (2004): The Art of the Start, Penguin Publishing Group
- Moore, Geoffrey A. (2002).: Crossing the Chasm, HarperCollins
- Osterwalder, Alexander / Pigneur, Yves (2010): Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers, John Wiley & Sons
- Ries, Eric (2011): The Lean Startup, Penguin Books Limited
- Thiel, Peter (2014): Zero to One: Notes on Startups, or How to Build the Future, Crown Business
- Timmons, Jeffry A. / Spinelli, Stephen (2009): New Venture Creation,7thedition, McGraw Hill Professional

**Responsible for Module:**
Bücken, Oliver; Dipl.-Kfm. (Univ.)

**Courses (Type of course, Weekly hours per semester), Instructor:**
Business Plan - Basic Course (Business Idea and Market) (MGT000159, English) (Seminar, 4 SWS)
Heyde F
For further information in this module, please click campus.tum.de or here.

## Module Description

### MGT001347: Innovation Facilitator | Innovation Facilitator

Version of module description: Gültig ab summerterm 2022

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>130 | **Contact Hours:**<br>50 |

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

**Description of Examination Method:**
Combination of group and individual project assignment - final examination consists of two components, each carrying 50% of the final course grade: (1) a 5 minute group presentation plus 10 minutes Q&A and feedback at the end of the course and (2) an individual reflection paper of ca. 2,500 words.
Students will present to the class, the lecturer and the partner how the team identified an attractive opportunity in a suitable market, understood the customers' / users' needs in the process and, as a result, proposed a sustainable business model that balances people, planet and profit.

In a written reflection paper, every student will reflect upon and consolidate their individual learnings from (1) the training on high-performing teams, (2) the reading package and (3) their entrepreneurial experience on three different levels - self, team and entrepreneurship.
As part of the reflection, every student will anonymously read reflection papers of their peers. The peer feedback will foster students' ability to analyze the work of others as well as their own work and to give and receive effective feedback.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Practical experience in applying Design Thinking and Business Design as well as distinct ability to work in a team and great interest in working with individuals and teams

**Content:**
Supported by a training on building a high-performing team and the reading package students will work on five intensive days in interdisciplinary teams on a challenge from a partner and learn why and how to develop customer and user centric business ideas through applying an entrepreneurial mindset and innovative methods -  always considering the triple bottom line.

Taking on an embedded view on the interrelatedness of economic, social and environmental systems, students will develop an ecosystem map to get an overview of relevant stakeholders and potential customers as well as important relationships and value streams. Input on Empathy Research will prepare them to collect qualitative insights from potential customers and users through interviews, immersion and contextual observations.
After conducting their Empathy Research they will step by step learn how to synthesize their insights and define opportunities for sustainable innovation. With a concrete how-might-we-question they will start into ideation. Through different creativity methods they will develop and prioritize ideas and build a simple prototype. This prototype is being tested again through qualitative tests with potential customers and users. When they come back after testing they do a first iteration based on the feedback they got and derive assumptions on a potential business model. After input on pitching they will prepare slides or other material and pitch in front of the group, partner and external guests. After the pitch event they will be led through a reflection of the learnings they gained during the week. The reading package will support the transfer of these learnings.

**Intended Learning Outcomes:**
By the end of the semester students will be able to understand and apply life-centered design principles in the early stages of an entrepreneurial process: from identifying an entrepreneurial opportunity and understanding its environmental and social impact to validating assumptions by applying qualitative research methods and interpreting data as well as using prototyping as a tool for communication and learning. They will be able to apply creativity methods, take over collective responsibility and know how to effectively communicate their business opportunities.
They will have deepened their methodological knowledge in Design Thinking and sustainable business design and have the ability to apply it in following founding projects or a lead role in an innovation team. At the same time, they will have experienced working in a diverse, self-organized team and they will have learned to actively create a setting in which teams can work together effectively by giving and receiving feedback, moderating discussions, defining project goals and reacting to changes.

**Teaching and Learning Methods:**
This module relies on a combination of readings, input sessions, workshops, teamwork and individual feedback and support. While input sessions will stimulate students' engagement with relevant tools and topics, workshops and team discussions will support the implementation of the knowledge in their projects and facilitate students' learning of the soft and intricate aspects of adopting an entrepreneurial mindset and skills. Working on a design challenge that a partner (e.g. TUM Venture Labs) provides stimulates peer competition and allows students to directly apply what they learn in a real life setting. The reading package will strengthen students' understanding of the methods and allow them to make sense of their practical experience.

**Media:**
Presentations, Canvas, handywork

**Reading List:**
Each semester students will be provided with a mandatory reading package.

**Responsible for Module:**
Alexy, Oliver; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Innovation Facilitator (MGT001347, englisch) (Seminar, 4 SWS)
Alexy O [L], Hagleitner F
For further information in this module, please click campus.tum.de or here.

## Module Description

### MGT001348: Innovation Sprint | Innovation Sprint

Version of module description: Gültig ab summerterm 2022

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|---|---|---|---|
| **Module Level:**<br>Bachelor | **Language:**<br>German/English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>140 | **Contact Hours:**<br>40 |

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

**Description of Examination Method:**
Combination of group and individual project assignment - final examination consists of two components, each carrying 50% of the final course grade: (1) a 5 minute group presentation plus 10 minutes Q&A and feedback at the end of the course and (2) an individual reflection paper of ca. 2,500 words.
Students will present to the class, the lecturer and the partner how the team identified an attractive opportunity in a suitable market, understood the customers' / users' needs in the process and, as a result, proposed a sustainable business model that balances people, planet and profit.

In a written reflection paper, every student will reflect upon and consolidate their individual learnings from (1) the reading package and (2) their entrepreneurial experience on three different levels - self, team and entrepreneurship.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Interest in entrepreneurship and sustainability, ability to work in a team

**Content:**
Supported by the reading package students will work on five intensive days in Campus only in interdisciplinary teams on a challenge from a partner and learn why and how to develop customer and user centric business ideas through applying an entrepreneurial mindset and innovative methods - always considering the triple bottom line.
Taking on an embedded view on the interrelatedness of economic, social and environmental systems, students will develop an ecosystem map to get an overview of relevant stakeholders and potential customers as well as important relationships and value streams. Input on Empathy

Research will prepare them to collect qualitative insights from potential customers and users through interviews, immersion and contextual observations.
After conducting their Empathy Research they will step by step learn how to synthesize their insights and define opportunities for sustainable innovation. With a concrete how-might-we-question they will start into ideation. Through different creativity methods they will develop and prioritize ideas and build a simple prototype. This prototype is being tested again through qualitative tests with potential customers and users. When they come back after testing they do a first iteration based on the feedback they got and derive assumptions on a potential business model. After input on pitching they will prepare slides or other material and pitch in front of the group, partner and external guests. After the pitch event they will be led through a reflection of the learnings they gained during the week. The reading package will support the transfer of these learnings.

**Intended Learning Outcomes:**
After participating in this module students will be able to understand and apply life-centered design principles in the early stages of an entrepreneurial process: from identifying an entrepreneurial opportunity and understanding its environmental and social impact to validating assumptions by applying qualitative research methods and interpreting data as well as using prototyping as a tool for communication and learning. They will be able to apply creativity methods, take over collective responsibility and know how to effectively communicate their business opportunities.
Taking decisions under uncertainty, ambiguity and risk in newly formed teams will foster their collaboration and communication skills and prepare them for future team work in appreciating and accommodating team members' individual personalities and boundaries.
At the same time the reading package enables students to gain a broader understanding of the methods learned in the course providing them with the ability to apply them beyond the context of innovation.

**Teaching and Learning Methods:**
This module relies on a combination of readings, input sessions, workshops, teamwork and individual feedback and support. While input sessions will stimulate students’ engagement with relevant tools and topics, workshops and team discussions will support the implementation of the knowledge in their projects and facilitate students’ learning of the soft and intricate aspects of adopting an entrepreneurial mindset and skills. Working on a design challenge that a partner (e.g. TUM Venture Labs) provides stimulates peer competition and allows students to directly apply what they learn in a real life setting. The reading package will strengthen students' understanding of the methods and allow them to make sense of their practical experience.

**Media:**
Presentations, canvas, handywork

**Reading List:**
Each semester students will be provided with a mandatory reading package.

**Responsible for Module:**
Alexy, Oliver; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Innovation Sprint (MGT001348, englisch) (Seminar, 4 SWS)
Alexy O [L], Hagleitner F
For further information in this module, please click campus.tum.de or here.

# Module Description

## WI000813: Technology Entrepreneurship Lab | Technology Entrepreneurship Lab

Version of module description: Gültig ab summerterm 2018

| **Module Level:** Master | **Language:** English | **Duration:** one semester | **Frequency:** winter/summer semester |
|---|---|---|---|
| **Credits:*** 6 | **Total Hours:** 180 | **Self-study Hours:** 120 | **Contact Hours:** 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 project work.
With the project work students show their understanding of the processes associated with the recognition and development of entrepreneurial opportunities. Students show that they are able to analyze the development of entrepreneurial teams. Moreover, they show their ability to apply coaching tools.
Throughout the project work each student has to hand in regular written documentation of maximum one page in which to describe the continuous development of the entrepreneurial idea as well as the team (60%). At the end of the project work each student has to hand in a summary documentation of maximum three pages (40%) covering idea development, team development and used tools.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
First entrepreneurial experience (in any field)
First team development experience (in any filed)
Ideally already taken part in Tech Challenge (WI 001180) or Business Plan Basic Seminar (WI000159)

**Content:**
In cooperation with UnternehmerTUM GmbH.
The module Technology Entrepreneurship Lab offers a "hands-on-experience" for the development of entrepreneurial business ideas and opportunities with

teams. Students work full-time for three consecutive days on the development of their entrepreneurial, technological and coaching skills. The students document both, the opportunity development process and the parallel team development process and present both processes. Subsequently, they will work on their teams' development of an opportunity assessment plan for the respective business ideas.

**Intended Learning Outcomes:**
After module participation students are able to understand the processes associated with the recognition and development of entrepreneurial opportunities. In addition, they are able to analyze the development of entrepreneurial teams and to apply coaching tools for this purpose. Further, they are able to develop an opportunity assessment plan as well as guide others in this process.

**Teaching and Learning Methods:**
The module consists of a three-day introductory lecture on entrepreneurial, technological and coaching skills as well as a hands-on 3 month execution phase with teams. A coach accompanies this process. The business ideas and team development processes are supervised and presented.

**Media:**
PowerPoint, Flipchart, online communication tool, virtual meetings, online webinars

**Reading List:**
Hisrich, R. D./Peters, M. P./Shepherd, D. A.: Entrepreneurship, 8th edition, McGraw-Hill, 2010

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

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

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

## Module Description

### WI000997: Marketing Entrepreneurship Lab | Marketing Entrepreneurship Lab

Version of module description: Gültig ab summerterm 2013

| Module Level: Master | Language: English | Duration: one semester | Frequency: winter/summer semester |
|---|---|---|---|
| **Credits:*** 6 | **Total Hours:** 180 | **Self-study Hours:** 150 | **Contact Hours:** 30 |

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

**Description of Examination Method:**
The grading is based on a presentation, a reflection paper and participation.
final presentation as a group (40%)
individual written reflection paper (40%)
class participation (20%)
mandatory participation of all
The seminar is on application:
https://academy.unternehmertum.de/programs/marketing-entrepreneurship-lab

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
Learn from Max Wittrock, marketing expert and co-founder of jokolade and mymuesli, practical marketing and business knowledge and apply your marketing skills to real world Start-ups.
At the Marketing Entrepreneurship Lab students get the opportunity to improve their marketing knowledge and apply it to a real world challenge. Support a Start-up of your choice with a course-related project in the areas of strategic marketing, market research, product launch, etc (also possible as a team). The following topics are covered among others in the course:
• How do you create a marketing plan and decide on a strategy?
• How do you measure marketing effectiveness?
• The basics of Public Relations, Storytelling, and Social Media Marketing
• How to plan a Start-up market entry?
• How to balance budget and goals?

• The correlation of startup business models and marketing

**Intended Learning Outcomes:**
Have better understanding of marketing challenges and tools. Enable students to apply their theoretical knowledge about marketing and gain new capabilities in a professional and more practical direction by relating to real life startup marketing challenges.
Equip student with practical skills beyond the traditional marketing curriculum and thus close bridge students with startup founders to better equip them for working in a startup.

**Teaching and Learning Methods:**
lectures
group works
project-based learning
real Start-up cases

**Media:**
hybrid format, blocked seminar, presentation, discussion, clinic

**Reading List:**
will be presented at the start of the seminar

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

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

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

## Module Description

### WI001141: Principled Entrepreneurial Decisions | Principled Entrepreneurial Decisions [PED]

*How to make game-changing decisions*

Version of module description: Gültig ab winterterm 2017/18

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>140 | **Contact Hours:**<br>40 |

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

**Description of Examination Method:**
Mandatory participation on all workshop days
(1) active class participation (25%)
(2) short assignement questions on cases (25%)
(3) presentation of values and principles for their company/project/future startup (25%)
(4) reflection paper, 2-3 pages, max 1.200 words (25%)
The seminar is on application:
https://academy.unternehmertum.de/programs/principled-entrepreneurial-decisions

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Application & willingness for active participation
being or becoming part of a Startup or project team
Students who are interested in Venture Capital and decision-making of founders are also welcome

**Content:**
This course will challenge the next generation of leaders and entrepreneurs to think critically about how their personal values and principles inform the difficult decisions they will have to make as they grow their business. The course will first equip students with frameworks to crystalize their own values and principles. Students will learn to apply their own core values. A selection of readings and case studies will provide students with tangible examples of the challenges other entrepreneurs have faced. Each class will be highly immersive, featuring conversations with entrepreneurial guest speakers and break-out sessions. Through conversations with case

protagonists and each other, students will leave the class more prepared to navigate the ethical dilemmas that they may encounter during their professional lives.

**Intended Learning Outcomes:**
1_students are able to brave difficult situations in the startup context
2_Enable students to begin to craft their own framework – personal and company
3_Discuss case examples (i.e. Flixbus, Konux, ProGlove, Luminovo, fernride, Reactive Robotics, Grupon, buecher.de, SevDesk, inveox, 10X, ...) and conduct exercises to help them on their journey

**Teaching and Learning Methods:**
lectures
group works
role plays
real Start-up cases with the founders in class
discussions

**Media:**
presentations
founders in class
video

**Reading List:**
Dalio, R. (2017). Principles: Life and work. New York, NY
Horowitz, B., & Kenerly, K. (2014). The hard thing about hard things: building a business when there are no easy answers. New York, NY: Harper Business.
More literature will be provided in class

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

**Courses (Type of course, Weekly hours per semester), Instructor:**
Principled Entrepreneurial Decisions (WI001141, englisch) (Seminar, 4 SWS)
Bücken O
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0060: Business Game in Sustainable Management | Business Game in Sustainable Management

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Because of the mediation of competences and the interactive character of the module using the supply chain  simulation „The Fresh Connection“ several group presentations are part of the evaluation:
- Introductory presentation for a supply chain topic (30 minutes / 50% of the evaluation)
- Short presentation concerning decision alternatives within a round of the simulation (10 minutes / 20% of the evaluation)
- Presentations of the decisions made within the respective rounds of the simulation, the lessons learnt and the results (15 minutes / 30% of the evaluation)

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Supply Chain Planning

**Content:**
The module is an innovative combination of mediation of theoretical background knowledge, practice and experience using the supply chain simulation „The Fresh Connection“. The topics in detail:
- Basics and decision making in supply chain management
- Supplier Management
- Demand Management
- Capacity and Production Management
- Inventory Management and Planning
- Supply Chain Mapping and component characteristics
- Supply Chain Strategy

- Variables and KPI‘s on strategic and tactical level
- External Collaboration

**Intended Learning Outcomes:**
The students will obtain a practice oriented overview of basics, decisions and interrelations in supply chain management. The students will achieve the ability to understand influencing factors and consequences of supply chain decisions with the help of the simulation “The Fresh Connection“. The students will achieve the competence for autonomous academic self study and application-oriented presentation of content. A focus of the mediation of competences is on work in cross-functional teams.

**Teaching and Learning Methods:**
Lecture, Web-based supply chain management simulation and learning environment, self study and group work with presentation of result

**Media:**
Lecture, simulation software, presentations

**Reading List:**
Fisher, M.L. , What is the right supply chain for your product?, Harvard Business Review, March-April 1997
Christopher, M. , Logistics and Supply Chain Management, creating value-added networks, Prentice Hall, 2005
Chopra, S. and Meindl, Supply Chain Management, Pearson Education, third edition, 2007

**Responsible for Module:**
Alexander Hübner alexander.huebner@tum.de

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

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

# Module Description

## CS0078: Advanced Seminar in Innovation and Technology Management | Advanced Seminar in Innovation and Technology Management

Version of module description: Gültig ab winterterm 2024/25

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The learning results are going to be proved in form of a written thesis. The students write a theoretical and/or empirical thesis of 15-20 pages depedning on the type of current research problem in the area of Innovation and Technology Management. They prove that they have understood the content of the current academic literature and are able to conduct empirical analyses.

**Repeat Examination:**

**(Recommended) Prerequisites:**
Innovation in Bioeconomy

**Content:**
Current research questions from the area of Innovation and Technology Management, e.g., Ecosystems, sustainable innovation, digitization.

**Intended Learning Outcomes:**
After successful completion of the module the students are able to derive an advanced academic research question and to respond to it by using the relevant literature in the area of innovation and technology management. The research questions are typically related to the promotion of sustainable innovation or entrepreneurship within ecosystems. In addition to the required literature analysis based on peer-reviewed academic journals, the students are able to conduct and interpret relevant empirical analyses.

**Teaching and Learning Methods:**
Teaching methods: The students will be familiarized with the basics to conduct literature reviews in the area of innovation and technology management and to conduct and interpret empirical analyses using statistical programs like STATA, R or Python. The students apply these contents to their own research questions in the thesis. The students present their results in front of the other seminar members, and discuss their results with the group.
The students have to write a seminar thesis in order to learn how to write an academic paper based on a relevant research question in the area of innovation and technology management.

**Media:**
Presentations, Power-Point Slides

**Reading List:**
Relevant research papers will be provided

**Responsible for Module:**
Claudia Doblinger claudia.doblinger@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Seminar in Innovation and Technology Management (Seminar, 4 SWS)
Doblinger C [L], Doblinger C
For further information in this module, please click campus.tum.de or here.

## Module Description

### CS0096: Advanced Empirical Research Methods | Advanced Empirical Research Methods

Version of module description: Gültig ab summerterm 2024

| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
|---|---|---|---|
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>120 | **Contact Hours:**<br>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 seminar paper with a maximum length of 15 pages. The students analyze a provided data set based on an individually posed question. The results are written down and submitted in the form of a seminar paper that has the structure of a scientific paper. The length of the seminar paper is a maximum of 15 pages. The students should be able to select, justify and implement suitable econometric methods for economic impact assessment based on the given question.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Statistics

**Content:**
Selected statistical methods required for impact analysis in the economics field, e.g. Difference in Difference, Propensity Score Matching, Instrumental Variable Method. Problems of endogeneity and selfselection bias during data collection and analysis. Conception of suitable data collections. The methods will be presented in the lecture. As part of the exercise, its application is carried out on concrete case studies

**Intended Learning Outcomes:**
After attending the module, students will be familiar with the most important statistical methods in the field of Impact Assessment to address the problem of endogeneity and the selfselection bias in economic and social sciences. They are able to select and execute the appropriate statistical models for specific case studies. They know how to collect data themselves in order to perform

such impact assessment. In addition, students are able to understand statistics in scientific literature (peer reviewed journals).

**Teaching and Learning Methods:**
The lecture and exercise will be done using Powerpoint and Stata. In addition, scientifically published studies will be integrated into the lectures. In the exercise, the students themselves analyze data sets that are made available. The results of the case studies are then discussed and questioned individually and / or in groups from different perspectives by the students. Scientific publications using statistical analysis are analyzed and discussed by the students.

**Media:**
Presentations, slide scripts, Articles

**Reading List:**
Kleiber & Zeileis (2008): Applied Econometrics with R, Springer; Angrist & Pischke (2009): Mostly Harmless Econometrics: An Empiricist's Companion, Princeton Univers. Press.

**Responsible for Module:**
Faße, Anja; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Empirical Research Methods (Lecture) (Vorlesung, 2 SWS)
Faße A [L], Faße A

Advanced Empirical Research Methods (Exercise) (Übung, 2 SWS)
Faße A [L], Richter S, Shayo G
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0098: Operations Research | Operations Research

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Assessment takes the form of a written examination. In that examination, students must demonstrate their ability to formulate and solve decision models with appropriate methods. Type of assessment: in writing  duration of assessment: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Bachelor Business administration; advanced knowledge of mathematics and statistics

**Content:**
The module is divided into six distinctive areas:

Part 1: Basic Concepts
Part 2: Quantitative Modelling
Part 3: Linear Optimization
Part 4: Graph Theorie
Part 5: Integer and Combinatorical Optimization
Part 6: Dynamic Optimization

**Intended Learning Outcomes:**
The course introduces fundamental and advanced methods for modeling and solution of business problems with concepts from Operations Research (OR). Students will be introduced to using quantitative methods for planning and decision-making in companies and societies. Students will apply analytical methods of problem-solving and decision-making that is useful in the management of organizations.

**Teaching and Learning Methods:**
Lecture (theory), tutorials with group work and presentation

**Media:**
Seminaristic tution using beamer, overhead projector, flipchart

**Reading List:**
Hilier, F. and Lieberman, G., Introduction to Operations Research, McGraw-Hill, 2009
Kallrath, J and Wilson, J. M., Business Optimisation using mathematical Programming, London (Macmillan) 1997
Winston, W.: Operations Research - Applications and Algorithms. 4th ed. (internat. student ed.), Belmont, Calif. (Duxbury), 2004.
Taha, H. A., Operations Research, 7th ed., Upper Saddle River, N.J. (Prentice Hall) 2003.
Domschke, W., Drexl, A., Klein, R., Scholl, A, Einführung in Operations Research, Berlin (Springer) 2015.
Domschke, W. et al., Übungen und Fallbeispiele zum Operations Research, Springer, Berlin–Heidelberg, 2015

**Responsible for Module:**
Hübner, Alexander; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Operations Research (Vorlesung mit integrierten Übungen, 4 SWS)
Hübner A [L], Hübner A, Riesenegger L
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0111: Advanced Development Economics | Advanced Development Economics

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
The examination will be given in the form of a written examination. The students should be able to evaluate and justify general and detailed theories, methods and concepts of the environmental and resource economy. Important international examples will be explained. Type of examination: written, no additional tools allowed, duration of examination: 60 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Micro- and Macroeconomics

**Content:**
Why are some countries developing and some are trapped in poverty? What are the determinants of economic growth? What is the role of demography, institutions (in particular the state), the environment, labor, migration, capital or credit markets in the development of states? What is the importance of development aid & cooperation? These are some of the questions that decision-makers in the developed and developing countries have to discuss every day. This course provides a theoretical foundation and empirical evidence for the analysis of the most important questions of today's development of the world.

**Intended Learning Outcomes:**
After visiting the module, the students can use the development economy to understand what is hindering development and what factors lead to success. They can apply theories, concepts, and analytical techniques associated with macroeconomics. Students learn to understand the difference between growth and development, the reasons and impact of migration, the role of institutions (e.g. properte and use rights), development cooperation and international trade. The

students are able to analyze empirical evidence on economic development and to critically read the literature in the field of economic development.

**Teaching and Learning Methods:**
The lecture and the exercise will be done by PowerPoint. In addition, current examples from newspapers and journals will be integrated into the lectures. In the exercise, the students research current case studies linked to the theories and concepts presented in the lecture. These case studies are then individually and / or groupwise discussed and questioned from different perspectives together with the students. Web lectures by internationally renowned experts and researchers will be integrated into the lecture.

**Media:**
Presentations, slide scripts, Articles, online lecture examples

**Reading List:**
Alain de Janvry, Elisabeth Sadoulet (2016). Development Economics - Theory and Practice. Routledge; Michael Todaro, Stephen Smith (2012). Economic Development, Pearson.

**Responsible for Module:**
Faße, Anja; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Development Economics (Lecture) (Vorlesung, 2 SWS)
Faße A [L], Faße A

Advanced Development Economics (Tutorial) (Übung, 2 SWS)
Faße A [L], Faße A, Shayo G
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0113: Innovation in Bioeconomy | Innovation in Bioeconomy

Version of module description: Gültig ab winterterm 2024/25

| | | | |
|---|---|---|---|
| **Module Level:** Master | **Language:** English | **Duration:** one semester | **Frequency:** winter/summer semester |
| **Credits:*** 6 | **Total Hours:** 180 | **Self-study Hours:** 120 | **Contact Hours:** 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 written exam (90 Minutes). The written form of the exam allows a comprehensive assessment of students' knowledge and understanding of the principles of innovation management and entrepreneurship with a focus on bioeconomic questions and concepts. Building on a core understanding of the principles of innovation management and entrepreneurship, students will answer questions about the more recent innovation and entrepreneurship concepts and have the ability to explain the adapted strategies and options for new ventures firms. They will also be able to assess the relevance of technologies and resources related to the bioeconomy and the different options to design sustainable business models in the context of bioeconomic questions.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Entrepreneurship, Introduction to Innovation Management

**Content:**
The module introduces students into advanced principles of innovation management and entrepreneurship from a sustainable perspective. Students will be equiped with basic knowledge on:
- design of business models to implement sustainable innovation
- advanced methods to generate and implement sustainable innovation
- role of ecosystems and networks

Beyond that, students will engage in break-out group workshops to personally experience the process of developing and evaluating sustainable innovation activities. Students give presentations to the audience and discuss their results.

**Intended Learning Outcomes:**
Following the completion of the course, the students will be familiarized with theoretical concepts and empirical methods to:
• assess the different forms and contents for identifiying and organising entrepreneurial ideas and innovative solutions in the context of the Bioeconomy by including broader economic, environmental and societal effects
• derive recommendations about the design and practices of innovation management and entrepreneurship and how to implement sustainable innovation
• identify and evaluate environmental technologies and design scenarios for firms to implement sustainable innovation

**Teaching and Learning Methods:**
The module will combine several learning methods.
- The basic knowledge as well as real world examples and case studies will be provided through the lecture.
- Discussions in the lecture and active participation are encouraged and will contribute to deepen the understanding of the concepts introduced.
- In the tutorial, the academic concepts will be discussed and applied in case studies. The students will further apply (part of) their theoretical knowledge to real-world problems and present their results in teams. This format fosters team work.
- Students will get additional background knowledge from the scientific literature in private reading.

**Media:**
Presentation, Power-Point Slides, Case Studies

**Reading List:**
The reading list is compiled from the latest contributions of relevant scientific journals, including the Academy of Management Journal, Research Policy, Strategic Management Journal, and will be made available to the students.

**Responsible for Module:**
Doblinger, Claudia; Prof. Dr. rer. pol. habil.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Innovation in Bioeconomy (Lecture) (Vorlesung, 2 SWS)
Doblinger C [L], Doblinger C

Innovation in Bioeconomy (Exercise) (Übung, 2 SWS)
Doblinger C [L], Doblinger C, Fischer D
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0114: International Trade | International Trade

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
The examination will be given in the form of a written examination. The students should be able to evaluate and justify general and detailed theories, methods and concepts of the environmental and resource economy. Important international examples will be explained. Type of examination: written, no additional tools allowed, duration of examination: 60 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Micro- and Macroeconomics

**Content:**
Basics of trade theory, such as Gains of Trade are deepened. Effects of customs duties and non-tariff trade barriers, such as environmental standards are presented. It deals with the concept of Pollution Haven and Race to the Bottom. The World Trade Organization and its role in international trade will be presented and discussed on the basis of current trade agreements and conflicts.
In addition, the lecture gives an overview of the effects of trade on international resources consumption. In doing so, empirical trade models (e.g., Gravity Model) are used for clarification.

**Intended Learning Outcomes:**
Students develop an understanding of theories and empirical methods used in the analysis of international trade. They know how trade policy affects the competitiveness and well-being of society and can apply these methods to the core issues of the globalization debate and sustainable trade.

**Teaching and Learning Methods:**
The lecture and the seminar will be done by PowerPoint. In addition, current examples of trade policy from the media and journals will be integrated into the lectures. In the seminar, the students research current case studies on the theories and concepts presented in the lecture. These case studies are then individually and / or groupwise discussed and questioned from different perspectives together with the students. Empirical trade models are used and discussed.

**Media:**
Presentations, slide scripts, Articles

**Reading List:**
Krugman, Obstfeld (2016) International Economics: Theory and Policy, Global Edition; Michael Todaro, Stephen Smith (2012). Economic Development, Pearson.

**Responsible for Module:**
Prof. Dr. Anja Faße

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

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

# Module Description

## CS0117: Consumer Studies | Consumer Studies

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
The examination will be given in the form of a written examination as well as students' presentations. The students should be able to evaluate and use the methods of consumer and market research that were thought in the module. No additional tools are allowed during written examination. Duration of written examination: 60 minutes. The proportion of the written examination is 50% of the total grade.
The students' presentations aim to present the scientific methods and results of a student project elaborated during the semester. The students present individually or in groups the elaborated results and discuss them with their colleagues and lecturer. Powerpoint and presentation equipment are allowed for the presentations. Students must give an intermediate presentation (duration: 10 minutes) and a final presentation (duration: 20 minutes). Students will only be admitted to the final presentation if they have successfully completed the interim presentation The proportion of the presentations is 50% of the total grade.
Both parts of the grade (written examination and presentation) must be passed in order to successfully complete the module.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge in statistics

**Content:**
The content of the module comprises of theory and analysis tools related to consumer behavior as well as their practical implementation. After a general introduction into the theory of consumer behavior the following topics will be covered in the module: consumption models, attitudes, involvement, knowledge, motives, lifestyles and other psychographic constructs. Additionally the students will become familiar with qualitative and quantitative market research methods. Different

survey tools will be introduced for practical implementation. The same is true for statistical data analysis packages (like e.g. SPSS, R) or qualitative analysis tools.
Additionally, the students use the learnt methods and tools to answer selected questions related to consumer behavior in biobased products or products based on regenerative resources.

**Intended Learning Outcomes:**
After attending the module, students will be familiar with the determinants of consumer behavior. They are able to understand and use different methods of market and consumer research. They are able to select and execute various methods of data collection (e.g. surveys, observational methods), to statistically analyse the collected data or use qualitative analysis tools, and interprete the results of the analysis. In addition, students can use the theoretical knowledge that is taught in the module to elaborate and implement own solutions to actual questions in the area of consumer behavior.

**Teaching and Learning Methods:**
The lecture will be done using Powerpoint and and statistic programs to data analysis. In addition, scientifically published studies will be integrated into the lectures. In the students' project, students use the theoretical knowledge and learnt methods of consumer and market research to analyse specific scientific questions related to consumer behavior. Finally, students will present and discuss their approach and results with their collegagues and lecturers.

**Media:**
Presentations, slide scripts

**Reading List:**
Mayring, P. (2014): Qualitative content analysis: theoretical foundation, basic procedures and software solution.
Klagenfurt. https://nbn-resolving.org/urn:nbn:de:0168-ssoar-395173
Backhaus, K.; Erichson, B.; Gensler, S. Weiber, R., Weiber,  (2021): Multivariate Analysis – An Application-Oriented Introduction Berlin, Springer
Hoffmann, S.; Akbar, P. (2023): Consumer Behavior. Berlin, Springer

**Responsible for Module:**
Decker, Thomas; 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

# CS0118: Environmental Accounting in Economics and Sustainability Sciences | Environmental Accounting in Economics and Sustainability Sciences

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
The examination will be given in the form of a written examination. The students should be able to evaluate and justify general and detailed theories, methods and concepts of the environmental accounting in economics. Example problems will have to be explained, solved and discussed. Type of examination: written, no additional tools allowed, duration of examination: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Micro- and Macroeconomics, Advanced Sustainability and Life Cycle Assessment

**Content:**
Fundamentals of the national accounts (input-output analysis) and the extension to environmental and social accounts (NAMEA, Social Accounting matrix). Integration of environmental accounts through physical and monetary environmental accounts and their advantages and disadvantages. Execution of multiplier analyzes with Excel. Use of input-output analysis and its environmental extensions for material flow analysis. Dynamic and multi-regional input-output approaches and hybrid Life Cycle Assessment.

**Intended Learning Outcomes:**
After the module, students will be able to understand and develop the system of national accounts and the integration of environmental accounts (monetary and physical) at national and regional level. They are able to perform and interpret a multiplier analysis. They use advanced methods of input-output analysis to solve problems in material flow analysis.

**Teaching and Learning Methods:**
The lecture and the tutorial will be done by Powerpoint and Excel. In addition, current examples from scientific journals and data sets will be integrated into the lectures. For advanced examples the use of a mathematical software suite such as Matlab and input-output as well as life cycle inventory databases is intended. These case studies are then analyzed and discussed individually and / or in groups from different perspectives together by the students.

**Media:**
Presentations, slide scripts, Articles

**Reading List:**
Taylor (2008): Village Economies: The Design, Estimation, and Use of Villagewide Economic Models. Cambridge University Press; Anguita & Wagner (2010): Environmental Social Accounting Matrices: Theory and Applications, Routledge. Brunner/Rechberger (2017): Handbook of Material Flow Analysis, CRC Press; Miller/Blair (2009): Input-output Analysis: foundations and extensions, Cambridge University Press; and recent journal articles (to be announced in the lectures)

**Responsible for Module:**
Anja Faße

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

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

# Module Description

## CS0119: Behavioral Public Economics | Behavioral Public Economics

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
The examination will be given in the form of a written examination. The students should be able to describe theories, methods and concepts of Behavioral Public Economics. Students should be able to explain important examples from the academic literature. Type of examination: written, calculators are allowed, no additional tools allowed, duration of examination: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Microeconomics, Advanced Microeconomics

**Content:**
In this course combines public economics with recent contributions of behavioral economics. Students will learn how to apply findings from behavioral economics to the public sector. This course will combine standard models from text books with recent academic papers. We will cover classic theories, their behavioral extensions, and empirical studies. Cover topics will be:
- Welfare Analysis
- Taxation
- Public Goods / Externalities
- Political Economy (Politicians and Voting)
- Public Policy (Savings, Poverty, Health, Environment)

**Intended Learning Outcomes:**
After attending the module, students will understand current topics in Public Economics and know the relevant insight from behavioral economics. They are capable of applying economic theory to analyze current problems and they can reference the relevant empirical evidence. Students can

analyze and evaluate policy proposals. Based on existing examples they can design and discuss their own policy interventions.

**Teaching and Learning Methods:**
The lecture will be mostly done by presentations. In addition, articles from newspapers and journals are integrated into the lectures. Together with the lecturer, students will study the content and methods of the academic papers. In the exercises, students will practice solving the learned models. This will either be done jointly on the blackboard or as work in smaller groups. Classroom experiments are carried out for selected topics.

**Media:**
Presentations, slide scripts, Articles, online lecture examples

**Reading List:**
Atkinson, A. and Stiglitz, J. (1980), Lectures on Public Economics, McGraw-Hill; reprinted by Princeton University Press (2015).
Gruber, J. (2016) Public Finance and Public Policy, 5th edition, Worth Publishers.
Additional references of academic papers

**Responsible for Module:**
Goerg, Sebastian; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Behavioral Public Economics (Exercise) (Übung, 2 SWS)
Goerg S [L], Goerg S

Behavioral Public Economics (Lecture) (Vorlesung, 2 SWS)
Goerg S [L], Goerg S, Speckner M
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0120: Advanced Sustainability and Life Cycle Assessment | Advanced Sustainability and Life Cycle Assessment

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Written exam (90 minutes): Students have to solve problems from the thematic field of the module. They have to prove their ability to use the right vocabulary, apply their knowledge on advanced topics in life cycle and systems thinking, sustainability and and life cycle assessment. Learning aids: pocket calculator.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Fundamental knowledge in Life Cycle Assessment as demonstrated e.g. by the successful participation of the module Material Flow Analysis and Life Cycle Assessment or Principles of LCA.

**Content:**
The module contains units covering the following topics:
• Systems and life cycle thinking
• LCA following the ISO 14040/14044 and ILCD standards
• Extension of Life Cycle Assessment to Life Cycle Sustainability Assessments
• Advanced Life Cycle Impact Assessment Methods such as for
- Land use and land use change
- Water use
- Resource use
• Attributional and consequential assessments
• Regionalisation of inventories and impact assessments
• Hybrid approaches
• Uncertainty handling

• Interface with Multi Criteria Decision Analysis
• Presentation and visualisation of results
• Handling of data uncertainty
• Current trends and developments
• Software systems and data bases for material flow analysis and life cycle assessment
• Case studies

**Intended Learning Outcomes:**
The students use advanced concepts and tools of sustainability and life cycle assessment to assess products, services and processesregarding their environmental impacts. Thus, they are able to gain a deeper understanding of their underlying material and energy flows and how they impact the environment. With these competencies development and improvement of systems, products and services can be supported, decision support delivered and communication with stakeholders aided.

**Teaching and Learning Methods:**
Format: lecture and (computer-based) exercises to introduce the content, to repeat and deepen the understanding as well as practice individually and in groups.

Teaching / learning methods:
- Media-assisted presentations
- Group work / case studies with presentation
- Individual assignments and presentation
- Computer lab exercises using LCA software systems and Life Cycle Inventory Data bases.

**Media:**
Digital projector, board, flipchart, online contents, case studies, computer lab

**Reading List:**
Recommended reading:
• Curran, M.A. (2015): Life Cycle Assessment Student Handbook, Scrivener Publishing:
• Hauschild, M.Z. & Huijbregts, M.A.J. (2015): Life Cycle Impact Assessment (LCA Compendium - The Complete World of Life Cycle Assessment), Springer.
• Klöpffer, W. & Grahl, B. (2014): Life Cycle Assessment (LCA), Wiley-VCH.
• Recent articles from esp. International Journal of Life Cycle Assessment, Journal of Cleaner Production, Journal of Industrial Ecology, Environmental Science and Technology (to be announced in the lecture)

**Responsible for Module:**
Fröhling, Magnus; Prof. Dr. rer. pol.

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

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

# Module Description

## CS0121: Sustainable Production | Sustainable Production [SP]

Version of module description: Gültig ab winterterm 2020/21

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

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

**Description of Examination Method:**
Written exam (90 minutes): By solving problems from the thematic field of the module students have to prove their understanding of the management of industrial production processes and technologies under consideration of sustainability aspects. In doing so they have to prove their techno-economic understanding, knowledge on quantitative methods for the analysis, assessment and optimisation of production systems, as well as their analytical and verbal skills in the field. They need to show that they are able to discuss the treated approaches and to derive further research needs. Learning aids: pocket calculator.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
-

**Content:**
The module covers inter alia the following topics:
• Sustainability aspects of industrial production and consumption
• Reasons for considering sustainability aspects in production management
• Measuring sustainability of production and operations
• Sustainable product and service design
• Sustainable sourcing
• Sustainable production management
• Sustainability of logistics
• Managing wastes, waste water, air emissions and product returns

**Intended Learning Outcomes:**
The module aims at enabling students to approach management tasks of production systems under consideration of sustainability aspects. This covers especially , especially the analysis, assessment and optimisation of these using a quantitative systems analysis approach.

The students understand that production and consumption activities have sustainability impacts and why these have to be considered in the management of production systems. They apply quantitative approaches for the analysis, assessment and optimisation of these systems on example planning tasks. They are capable to discuss the approaches critically, derive further development needs and transfer these approaches to other fields.

**Teaching and Learning Methods:**
Format: Lecture with exercise to introduce, train and deepen the contents of the module.

Teaching / learning methods:
- Media-assisted presentations
- Group work / case studies with presentation
- Individulal assignments and presentation

The teaching and learning methods are combinded specifically for the treated topics. Typically, a thematic impulse or overview is given with a media-assisted presentation. Individual or group work assignments provide the possibility to apply the acquired competencies, to repeat and deepen these as well as to prepare the transfer to other fields.

**Media:**
Digital projector, board, flipchart, online contents, case studies

**Reading List:**
Recommended reading:
• Stark R; Seliger G, Bonvoisin J (2017): Sustainable Manufacturing - Challenges, Solutions and Implementation Perspectives , Springer
• Reniers G, Sörensen K, Vranken K (2013): Management principles of sustainable industrial chemistry, Wiley VCH
• McKinnon A, Browne M, Piecyk M, Whiteing A (2015): Green Logistics, Kogan Page
• Mangla S, Luthra S, Jakhar S K, Kumar A, Rana N P (2019): Sustainable Procurement in Supply Chain Operations, CRC Press

Further related reading, especially articles in international peer reviewed journals, will be provided in the kick-off meeting of the module.

**Responsible for Module:**
Fröhling, Magnus; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Sustainable Production (Vorlesung) (Vorlesung, 2 SWS)
Fröhling M [L], Heinrich V, Schirmeister J

Sustainable Production (Übung) (Übung, 2 SWS)
Fröhling M [L], Schirmeister J, Heinrich V
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0122: Personnel and Organizational Economics | Personnel and Organizational Economics

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
The examination will be given in the form of a written examination. The students should be able to describe theories, methods and concepts of Personnel and Organizational Economics. Students should be able to explain important examples from the academic literature. Type of examination: written, calculators are allowed, no additional tools allowed, duration of examination: 90 minutes. In order to be admitted to the examination, successful completion of a course assignment is required. In the assignment, students apply what they have learned and demonstrate in a group work that they can understand and present a current research paper.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Microeconomics, Advanced Microeconomics

**Content:**
In this course we develop a simple theoretical framework for thinking about firm-worker interactions (the principal-agent model). We use it to organize the large empirical literature on personnel motivation, personnel selection, and organizations as a whole. The relevant are:
- The principal-agent-problem
- Employee motivation
- Recruiting and wage setting
- Tournaments as incentives
- Teams

**Intended Learning Outcomes:**
After attending the module, students will understand the impact of individuals' incentives in organizations in general and at the workplace as a concrete example. Students will understand how to model diverging motives and incentives and how those may result in conflicts. In addition, they are capable of the interpreting and summarizing the empirical evidence on those topics. Students will learn about possible solutions to align the incentives within organizations and are capable of solving these problems with the help of models.

**Teaching and Learning Methods:**
The lecture will be mostly done by presentations. In addition, articles from newspapers and journals are integrated into the lectures. Together with the lecturer, students will study the content and methods of the academic papers. In the exercises, students will practice solving the learned models. This will either be done jointly on the blackboard or as work in smaller groups. Classroom experiments are carried out for selected topics.

**Media:**
Presentations, slide scripts, Articles, online lecture examples

**Reading List:**
Peter Kuhn, Personnel Economics, Oxford University Press;
Zusätzliches Literaturverzeichnis wissenschaftlicher Publikationen

**Responsible for Module:**
Goerg, Sebastian; Prof. Dr. rer. pol.

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

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

# Module Description

## CS0128: Corporate Sustainability Management | Corporate Sustainability Management [CSM]

Version of module description: Gültig ab summerterm 2023

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

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

**Description of Examination Method:**
Written exam (90 minutes): Students have to solve problems from the thematic field of the module. They have to prove their ability to use the right vocabulary, apply their knowledge on advanced topics in strategic and operational sustainability management.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
None

**Content:**
The Corporate Sustainability Management module includes a detailed discussion of the term sustainability (three-pillar model) and the history of the content. Based on this, the basic premises for sustainable management and sustainable economic activity are derived and discussed in a social, political, environmental, economic and corporate context. The national, European and international strategies for sustainable management are presented (e.g. bioeconomy, circular economy, green economy). Furthermore, established measurement concepts and key performance indicators (KPIs) for sustainability (e.g. resource productivity, life cycle costing) are discussed and applied to exemplary products and value chains within the framework of "Corporate Social Responsibility Reporting".

**Intended Learning Outcomes:**
After completion of the module, the students are able to understand sustainability concepts and to compare sustainability-oriented corporate profiles as a supplement to value-added corporate development. They can develop and apply concepts for the derivation, evaluation and operational integration of economic, ecological and social indicators. This enables the students to carry out

sustainability assessments based on common and innovative new measurement concepts and indicators and to apply the results in the company.

**Teaching and Learning Methods:**
The module includes a lecture and an exercise. During the lecture, the content is communicated by presentations and discussions. The lectures serves to communicate the theoretical basics and terms of sustainability management including small exercises for group work. The students are encouraged to further deepen their knowledge of the proposed literature. As the highest level of competence, the lecture communicates an understanding of the evaluation of various sustainability concepts for use in operational management.
In the exercise, the students deepen the knowledge they have acquired by case studies. The content of the lectures and exercises is deepened both in small working groups and in individual work. As the highest level of competence, the exercise conveys the step-by-step development and incorporation of sustainability concepts using case studies of real and fictitious company concepts to achieve strategic and operational targets for sustainable development of the selected company.

**Media:**
Presentations, slide scripts, case descriptions of real and fictitious companies with sustainability management problems

**Reading List:**
Müller-Christ, G. (2010) Sustainable Management. Introduction into Resource Orientation and Contradictory Management Rationalities. Baden-Baden: Nomos
Schellnhuber, H. J.; Molina, M.; Stern, N.; Huber, V.; Kadner, S. (2010): Global Sustainability. A Nobel Cause. New York: Cambridge University Press
Seliger, G. (2012): Sustainable Manufacturing. Shaping Global Value Creation. Berlin: Springer
Von Hauff, M.; Kleine, A. (2009): Nachhaltige Entwicklung (Sustainable Development). Grundlagen und Umsetzung (Basics and Implementation). München: Oldenburg Wissenschaftsverlag

**Responsible for Module:**
Röder, Hubert; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Corporate Sustainability Management (Lecture) (Vorlesung, 1 SWS)
Röder H [L], Röder H

Corporate Sustainability Management (Exercise) (Übung, 3 SWS)
Röder H [L], Röder H
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0169: Sustainable Supply Chain Management | Sustainable Supply Chain Management

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**

Exam: 50%
presentation: 50%

The combination of grading methods is necessary to evaluate the skills acquired in this course
- Written exam: 45 minutes written exam on presentation, recommended readings, and case studies
- Oral report/presentation: Preparation of an reports in tandem teams with presentation and discussion. The report can be provided as slide-based summary of the presentation. Objective is the preparation of and summary of a current research paper in the field of the lecture; the list of papers is provided at the beginning of the course; All parts have to be passed and cannot be retaken

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Bachelor Business administration; advanced knowledge of Mathematics, Statistics and Operations Research

**Content:**
The course covers decision-oriented aspects of SCM and discusses basic concepts, models, and methods for hierarchical planning in supply chains.This course content provides the foundation for a critical examination of planning systems from a theoretical and practical perspective. This builds the foundation to study case studies and papers with respect to sustainability.

**Intended Learning Outcomes:**
The students:
- know the conceptual structure of supply chain planning and understand basic concepts, models, and methods that are applied in supply chain management
- gain experience in the supply chain management using prevalent software systems and understand scope and limitations in supporting practical decision situations.
- hone their skills with respect to modeling and solving decision problems in sustainable supply chain management.

**Teaching and Learning Methods:**
Lecture (theory), tutorials with group work and presentation

**Media:**
Seminaristic tution using beamer, overhead projector, flipchart

**Reading List:**
Stadtler/Kilger/Meyr (2015): Supply Chain Management and Advanced Planning. Concepts, Models, Software, and Case Studies. 4. Aufl., Springer (Berlin).
Cachon/Terwiesch (2012): Matching Supply with Demand
Chopra/Meindl (2009): Supply Chain Management: Strategy, Planning, and Operation, Global Edition

**Responsible for Module:**
Alexander Hübner alexander.huebner@tum.de

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

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

## Module Description

### CS0174: Marketing for Biobased Products | Marketing for Biobased Products [MBBP]

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
The exam will be in form of an oral exam. By answering questions students have to show that they have understood and can apply the thaught specific principles of the marketing of bio-based products and industrial marketing. No additional tools are allowed during oral examination with a duration of 15 minutes. In a students' project, the students demonstrate the scientific analysis and possible solutions of specific questions related to a defined topic concerning the marketing of biobased products including industrial marketing. The results of the project work will be presented (20 min; passed/non-passed) by the students with subsequent discussion with the other students and the lecturers.
In this students' project, the students demonstrate understanding of specific questions related to a defined topic concerning the marketing of bio-based products and services. Students have to show in their presentation that they can analyse, solve and answer defined problems and questions related to this topic. Participants of the course show that they have done appropriate research work and are able to present their results. By answering follow-up questions related to their presentation they show that they have learned to put their research outcome into the relevant product and market context.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basic know-how related to marketing and markets of biobased products is recommended

**Content:**
The content of the module comprises in one part specific aspects of the marketing of biobased products and services. This part includes in particular the modification of methods and instruments of strategic marketing to this specific group of products and services (e.g. holistic character

of change in raw material basis, use of by-products and cycle approaches), the particular target groups of such products and their behavior (e.g. characteristics of related target groups, attitude-behaviour gaps), adaptations in the marketing-mix (e.g. specific benefits, labelling and identification of biobased products, avoidance of greenwashing, biomass logistics) as well as specific aspects related to the marketing of sustainability-oriented products and services (e.g. sustainable consumption and its barriers, sustainability evaluation and standards, Fair trade).
Industrial marketing will be thaught in a second part of the module with a focus on specific tasks of industrial marketing, characteristics of different transaction types, specific features of transactions and service offers in the business-to-business area, as well as the combination of value chains, customer integration and service offers. Additionally, the procurement of business and state organisations will be considered with a focus on uncertainty and information as important factors in the buying process as well as concepts to analysing a buying center.
Besides, the students will use the taught methods and tools in a students' project in which actual questions and case studies related to the marketing of biobased products and services under consideration of industrial marketing will be analysed and answered.

**Intended Learning Outcomes:**
After attending the module, students will be able to use the instruments and methods of strategic and operational marketing related to biobased products and services thereby considering the specific aspects of industrial marketing in this context. They can deflect specific target groups for biobased products and services, analyse their behavior and derive targeted marketing strategies and their operationalization. Additionally, students can analyse the specific characteristics and challenges of sustainability-oriented products and services and are able to assess these in form of adapted marketing strategies and concepts. Students can evaluate the principles and specific tools of industrial marketing and can use these in the field of biobased products and services. Besides, students can distinguish important theoretical and practical approaches related to the procurement of business or state organisations and rate those with the specific characteristics of biobased products and services.

**Teaching and Learning Methods:**
The lecture will be done using Powerpoint with specifically worked out presentation scripts. In addition, published studies, scientific papers and statistical data will be integrated into the lectures. In the students' project, students use the taught methods and instruments of the marketing of biobased products and services, industrial marketing as well as their factual knowledge to analyse actual questions and cast studies related to the application fields of biobased products and services and derive adapted marketing strategies and concepts. They will present and discuss their approach and solutions with their colleagues and the lecturers.

**Media:**
Presentation slides, actual literature and studies, online discussion forum (all lecture materials are available via Moodle)

**Reading List:**
Specific literature and documents will be provided to the topics of the lectures as well as the topics that are worked on in the student projects

**Responsible for Module:**
Menrad, Klaus; Prof. Dr.sc.agr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Specific aspects of the marketing of biobased products (Vorlesung, 1 SWS)
Menrad K [L], Menrad K

Applied marketing for biobased products (Projekt, 2 SWS)
Menrad K [L], Menrad K, Stelzl B

Industrial marketing (Vorlesung, 1 SWS)
Menrad K [L], Stelzl B
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0176: Service Operations | Service Operations

Version of module description: Gültig ab winterterm 2021/22

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

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

**Description of Examination Method:**
• The examination is carried out in the form of a written test. This should demonstrate that the students can formulate quantitative decision models in the service sector and solve them with suitable methods.
• Type of examination: written
• Exam duration: 60 minutes

**Repeat Examination:**

**(Recommended) Prerequisites:**
Content of the module „Operations Research“ is recommended

**Content:**
• The basic concepts are presented with slide-based lectures. The quantitative models and methods are presented and illustrated by means of examples. Practical applications of service management, e.g. for hospitals, airlines, retail or the service sector.
• These contents form the basis for a critical consideration from a theoretical-conceptual and practical-application-oriented point of view. Current research papers and system-supported case studies are used for this purpose.
• In addition to an introduction to service management, the course also includes location planning, quality management, benchmarking, methods of process optimization, personnel planning, inventory planning and revenue management in the service sector.

**Intended Learning Outcomes:**
• The students get to know quantitative methods of operations management in the service sector and their application in practice.

• The students learn and understand the basic models and methods for service operations management (especially quality and process management as well as capacity planning) and revenue management (especially price differentiation, capacity control, overbooking control and dynamic pricing). It is also about getting to know the possibilities and limits of the models for use in practice.
• The students deepen their knowledge with regard to the modeling and solving of decision problems in the decision fields mentioned above.

**Teaching and Learning Methods:**
The basic concepts are presented with slide-based lectures. The quantitative models and methods are presented and illustrated by means of exercise examples, including practical applications in service management, e.g. for hospitals, airlines, retail or in general in the service sector. These contents form the basis for a critical consideration from a theoretical-conceptual and practical-application-oriented point of view. Current research papers, case studies and textbooks are used as the basis for this.

**Media:**
Presentations, black board work, exercise sheets

**Reading List:**
• Fitzsimmons, J.A. und M.J. Fitzsimmons: Service Management – Operations, Strategy, and Information Technology. McGraw Hill, New York, 3. Auflage, 2001.
• Klein, R. und C. Steinhardt (2008): Revenue Management – Grundlagen und Mathematische Methoden, Berlin/Heidelberg, Springer
• Talluri, K.T. und G.J. van Ryzin (2005): Theory and Practice of Revenue Management, Boston, Springer

**Responsible for Module:**
Alexander Hübner

**Courses (Type of course, Weekly hours per semester), Instructor:**
Service Operations (Lecture) (Vorlesung, 2 SWS)
Hübner A [L], Hübner A

Service Operations (Exercise) (Übung, 2 SWS)
Hübner A [L], Hübner A, Lex E
For further information in this module, please click campus.tum.de or here.

## Module Description

# CS0177: Discrete Event Simulation | Discrete Event Simulation

Version of module description: Gültig ab winterterm 2023/24

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>135 | **Contact Hours:**<br>75 |

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

**Description of Examination Method:**
The examination consists of two individual tasks and a project work. The individual work is done as homework and is composed as follows:
• R-Statistics homework (10 % of the evaluation)
• AnyLogic homework (10 % of the evaluation)

The project work serves to evaluate the understanding in handling and application of simulations. For the project work the participants receive a randomly assigned extensive fictitious simulation problem. The project work consists of the presentation of the project plan, a project report, an oral presentation of 20 min and a discussion time of 10 min.

The evaluation of the project work is based on the following criteria:
• presentation of the project plan (10 % of the evaluation)
• written documentation of the project work (50% of the evaluation)
• presentation and discussion of the project work (20% of the evaluation)

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basic knowledge in mathematics and statistics, especially in probability theory and probability distributions as well as descriptive and inductive statistics

**Content:**
• Basics of simulation
• Steps in a Simulation Study
• Conceptual Modeling
• Introduction to ARIS: Representation of processes using event-driven process chains

• Data collection and modeling of input data
• Introduction to R: Analysis of distributions
• Modeling and implementation of simulation models
• Introduction to simulation software (e.g. AnyLogic) and basic as well as advanced simulation techniques
• Visualization of simulations
• Verification, Validation and Calibration of a simulation
• Methods for determining the simulation setting
• Statistical methods for the analysis of simulation results

**Intended Learning Outcomes:**
Students
• apply their knowledge of probability theory and probability distributions
• are able to analyze production and logistic systems, represent processes and design proposals for optimization.
• apply the necessary methodological knowledge for the independent execution of simulation studies.
• are able to apply simulation software such as AnyLogic practically.
• can present results of a simulation study and derive concrete recommendations for action from their analyses.

**Teaching and Learning Methods:**
The module consists of a lecture and an exercise, which take place weekly. In the lecture, the contents are derived together with the participants. The exercise repeats the lecture contents with examples and deepens core concepts through independent simulation and computational studies of selected problems. The students are supported in solving the exercises by the tutors.

**Media:**
Presentations, cases and solutions

**Reading List:**
• Kelton, W. D., R. P. Sadowski, and D. T. Sturrock, Simulation with Arena, 3. Aufl., Boston (McGraw-Hill) 2003.
• Law, A. M. and W. D. Kelton, Simulation Modeling and Analysis, 4. Ed., Boston (McGraw-Hill) 2007.

**Responsible for Module:**
Alexander Hübner

**Courses (Type of course, Weekly hours per semester), Instructor:**
Discrete Event Simulation (Lecture) (Vorlesung, 2 SWS)
Schäfer F [L], Schäfer F, Tuma N

Discrete Event Simulation (Exercise) (Übung, 2 SWS)
Schäfer F [L], Schäfer F, Tuma N
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0226: Corporate Strategy | Corporate Strategy

Version of module description: Gültig ab winterterm 2022/23

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

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

**Description of Examination Method:**
Group Project and Group Presentations: 60%; Online Exam (60 min.): 40%

**Repeat Examination:**

**(Recommended) Prerequisites:**
Basic knowledge of business administration

**Content:**
Students are introduced into the topic of corporate strategy based on a thorough understanding of what strategy means in the context of corporate management.  Further, students learn about key management analysis tools and whose application to real life scenarios by the means of case studies. Subsequently, corporate strategy is looked at from a regional, national and international perspective including the notion of innovation and the formation of competitive advantage.

**Intended Learning Outcomes:**
The students obtain knowledge in
• gaining a broad understanding about core themes of corporate strategy, related processes and theoretical underpinnings,
• understanding strategic analysis tools in the context of case studies  and further examples
• developing a critical understanding of strategy in the context of corporate management with the objective to improve strategic decision making, and
• obtaining the ability to develop managerial reports based on the above.

The student enhance their skills in
• evaluating presented information in a critical manner based on the information presented in the course,

• applying strategic analysis tools and interpret the results of such analysis,
• presenting the results of his/her work in a concise way to a larger audience, and
• connecting local/regional/national corporate strategy topics to an international context.

The student obtain further general qualifications in
• having insights into relevant topics and issues in the context of corporate strategy,
• applying relevant theoretical frame works to case studies and demonstrate an in-depth understanding of the results,
• planning and executing relevant project work in a timely fashion in the context of a group project,
• presenting and contextualizing relevant information, theories and issues of the corporate strategy domain (oral and written),
• discussing relevant information and topics with peers as part of the course, and
• connecting the concept of innovation to corporate strategy and business success

**Teaching and Learning Methods:**
The basic concepts are presented with slide-based lectures. The models and methods are presented and illustrated by means of exercise examples, including practical applications in corporate strategy management. These contents form the basis for a critical consideration from a theoretical-conceptual and practical-application-oriented point of view. Current research papers, case studies and textbooks are used as the basis for this.

**Media:**
Core text book, case studies, academic journal articles, lecture slides, relevant online content

**Reading List:**
Exploring Strategy by Johnson, Whittington and Scholes

**Responsible for Module:**
Prof. Alexander Hübner

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

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

# Module Description

## CS0227: LCA Case Studies | LCA Case Studies [LCA CS]

Version of module description: Gültig ab summerterm 2022

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
Written group assignment and oral group presentation: Students are training their skills in Life Cycle Assessment by carrying out and report a small LCA study including data collection. Students are free to use the openLCA software for modelling. Performing the calculations with spread-sheets is also fully accepted.

In groups of at least two persons, students identify and select a topic for their LCA case study. Each group has to perform all four phases of an LCA. This consists of
- Writing a goal and scope definition,
- Collecting data for carrying out the inventory analysis,
- Selecting suitable life cycle impact categories and performing a life cycle impact assessment,
- Interpreting the results, discussing the own study including its limitations by comparing it with other LCA studies/reports in the same/similar topic.
- Presenting the results in form of a presentation and a written report

The examination consists of three parts. The weighting is as follows:
(1) Goal and scope definition (20%)
(2) Final presentation (30%)
(3) Final report (50%)

In the Goal and Scope Definition (~5 pages), the topic and purpose of the LCA case study is established and decisions are made about the product system being studies. In drafting the goal and scope definition, students show that they are able to identify and select an object for analysis, to structure a problem and plan the outset and further steps of their study.

In the final group presentation (25'), students present their results and have to show that they are able to summarize their findings in a scientific presentation, discuss and defend them (15' for presentation, 10' for discussion).

In the final report (15-20 pages), the students show that they are able to perform a simple LCA case study. Moreover, they proof their study design in a transparent and logical way. By presenting the results of the LCA case study as well as discussing the findings and limitations, students proof their ability to find relevant literature, carry out a small LCA study and document the results of the process in a scientific paper.

**Repeat Examination:**

**(Recommended) Prerequisites:**
The contents of the module Advanced Sustainability and Life Cycle Assessment is required. It can be obtained in parallel to this seminar.

**Content:**
The module contains units covering the following topics:
• Systems and life cycle thinking
• Life Cycle Assessment
• Goal and Scope Definition to plan the outline of the LCA study
• Life Cycle Inventory for data collection and reconciliation
• Life Cycle Impact Assessment to assess the potential environmental impacts
• Handling of data uncertainty
• Literature research and current trends and developments
• Software systems and databases for life cycle assessment
• Case studies

**Intended Learning Outcomes:**
The students use the concepts and tools of life cycle assessment. The goal is to be able to analyse industrial metabolisms as well as products and services regarding their environmental impacts. Thus, students gain a deeper understanding of the LCA methodology and procedure by applying the theoretical knowledge to a practical example.
At the end of the module students are able to carry out an own LCA. This involves carrying out the four phases of an LCA study
• the goal and scope definition phase: to identify and select a suitable product or service system to carry out an LCA case study, explain the key aspects of the goal and scope definition and their relevance for the subsequent LCA phases, to define a functional unit and reference flow for the LCA case
• the inventory analysis phase: to collect the input/output data with regard to the system being studied.
• the impact assessment phase: to address the environmental aspects and potential environmental impacts throughout the life cycle of a product or a service system.
• the interpretation phase: the results of the life cycle inventory and life cycle impact assessment are summarized and discussed as a basis for conclusions, recommendations and decision-making in accordance with the goal and scope definition.

Applying LCA methodology can support further development and improvement of systems, products, and services. This can support decision-making processes, marketing and product/ service improvement in the context of various stakeholders.

**Teaching and Learning Methods:**
Seminar: In parallel to the lecture "Advanced Sustainability and Life Cycle Assessment", this seminar format provides the opportunity to apply the theoretical knowledge of LCA by applying it to a small LCA case study and gaining a deeper understanding of the LCA methodology. After an introduction to the topic, the students identify a product/service system to analyse, carry out a full LCA (incl. data collection, literature research). They receive intermediate feedback to a Goal and Scope Definition of their study. In a next step they carry out a full LCA. In this process they are supervised, receive materials, thematic input, advice in scientific work and continuous feedback in the seminar sessions. The seminar closes with a final presentation.

Teaching / learning methods:
• Kick-off meeting
• Media-assisted presentations
• Video-based tutorials for methodology (e.g. LCA software)
• Individual work and feedback consultations
• Group work / case studies with presentation
• Interim presentations / workshops
• Final group presentations
• Group assignments

**Media:**
Digital projector, board, flipchart, online contents, videos, case studies, LCA software, presentations

**Reading List:**
Recommended reading:
• Curran, M.A. (2015): Life Cycle Assessment Student Handbook, Scrivener Publishing.
• Fröhling, M.; Hiete, M. (2020): Sustainability and Life Cycle Assessment in Industrial Biotechnology. Springer, Cham.
• Guinée, J.B. (2002): Handbook on life cycle assessment: operational guide to the ISO standards. Kluwer, Dordrecht.
• Hauschild, M.Z. & Huijbregts, M.A.J. (2015): Life Cycle Impact Assessment (LCA Compendium - The Complete World of Life Cycle Assessment), Springer, Cham.
• Hauschild, M.; Rosenbaum, R.K.; Olsen, S.I. (2018): Life Cycle Assessment: Theory and Practice. Springer, Cham.
• Jolliet, O., Saade-Sbeih, M. (2015): Environmental Life Cycle Assessment. CRC Press.
• Klöpffer, W. & Grahl, B. (2014): Life Cycle Assessment (LCA), Wiley-VCH.

**Responsible for Module:**
Fröhling, Magnus; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
LCA Case Studies (Seminar, 3 SWS)
Fröhling M [L], Schirmeister J, Corella Puertas M
For further information in this module, please click campus.tum.de or here.

## Module Description

# CS0228: Technology and Management of Renewable Energies in a Global Context | Technology and Management of Renewable Energies in a Global Context [REAE]

Version of module description: Gültig ab summerterm 2024

| Module Level:<br>Master | Language:<br>English | Duration:<br>one semester | Frequency:<br>summer semester |
|---|---|---|---|
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
The exam will be in form of an oral presentation of the students (20+10 minutes; 75% of the grade) and a short report of the students' project work (max. 5 pages, not counting front page and cited literature; 25% of the grade).

In this students' project, the students demonstrate understanding of specific questions related to a defined topic concerning the technology and management of renewable energies in a global context. Students have to show in their presentation that they can analyse, solve and answer defined problems and questions related to this topic. Participants of the course show that they have done appropriate research work and are able to present their results. By answering follow-up questions related to their presentation they show that they have learned to put their research outcome into the relevant technical or country context. The presentation slides and the short report will be handed over to the lecturers and will be included in the grading.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basic know-how related to specific techniques of renewable energies (e.g. solar energy, wind energy, hydropower, biomass conversion technology, geothermal energy) as well as management of energy systems either on a company or on state level.

**Content:**
A) Technical aspects of different forms of renewable energies (e.g. current state of technology, technical options for the future, technical bottlenecks, scale-up possibilities)
- Wind power

- Hydropower
- Photovoltaics, solarpower
- Geothermal energy
- Biomass use for energy purposes
- Biofuels, electric vehicles, E-fuels
- Hydrogen
- Other forms of renewable energies

B) Economic aspects related to defined renewable energies (e.g. cost of use/production, cost structure and development in the past, learning curves, innovation and diffusion of renewable energies)
C) Influencing factors for adoption and use of renewable energies (e.g. natural/local conditions, availability of renewable resources, technical infrastructure, user structure of energy, cost and economic factors, financing, political and regulatory issues, social acceptance, behaviour of stakeholders and people)
D) Situation and development in a specific (country) context (e.g. governance, policy goals and activities, competing factors and interests (e.g. by fossil energy use or related companies/ stakeholders), legal and regulatory stability)

**Intended Learning Outcomes:**
At the end of the module, students will be able to analyse and elaborate solutions for existing problems related to the technology and management of renewable energies and apply such solutions to the specific context of selected countries worldwide. They consider both the technical side as well as the economic and management dimension in order to develop integrated solutions for a specific question related to renewable energies. Additionally they take the specific context and situation (e.g. technical infrastructure and know-how, maintenance, electrical or other grids, political and regulatory rules, economic framework, company and user structure) in one or several countries or regions into account when analysing and elaborating solutions for the question on-hand. They are able to apply their knowledge to create an oral presentation and a written summary of their findings. Presented results are discussed with the audience so that students are able to defend their solution and put it in an appropriate context.

**Teaching and Learning Methods:**
The module is a seminar, where course participants form (preferably international) teams that investigate a given topic by autonomously doing research work and discussing results within the team. During regular meetings with the lecturers questions can be discussed, next steps are defined and (interim) results are presented. Lecturers will provide basic and background material for the students as well as actual information for the given topics that are elaborated by the student teams.

Learning activities: Literature/document research, student group project

**Media:**
Presentation slides, online discussion forum (all lecture materials are available via Moodle)

**Reading List:**
Specific literature and documents will be provided to the topics that are worked on in the student projects

**Responsible for Module:**
Menrad, Klaus; Prof. Dr.sc.agr.

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

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

## Module Description

### CS0238: Environmental Behavior and Support for Climate Policies | Environmental Behavior and Support for Climate Policies

Version of module description: Gültig ab winterterm 2021/22

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

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

**Description of Examination Method:**
Achievement of desired learning objectives shall be verified in a term paper (max. 10 pages) and an oral presentation in a group. The students will implement their own online survey and present the findings in the context of the relevant literature in a group presentation (each student has to present 10 minutes). The oral presentation shall be assessed according to content and rhetoric aspects. The term paper is written individually and summarizes the relevant literature, empirical method, data, and key findings. Weighting: Term paper 2, Presentation 1.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
The successful transition from a fossil fuel economy to a more bio-based and sustainable circular economy requires pro-environmental behavior and public support for long-term climate policies (e.g., climate neutrality by 2050). This course aims to explain the factors of environmental behavior and why citizens support or reject climate change polices. Based on recent empirical findings from psychology and economics, the following factors influencing behavior and policy support are discussed:

- socio-psychological factors and climate change perception (e.g., political orientation, environmental values, risk perception, emotions, etc.),
- the perception of climate policy and design (e.g., perceived costs, perceived fairness, perceived effectiveness, etc.), and
- contextual factors (e.g., social norms, participations, economic and geographical aspects).

The course consists of a lecture that gives an overview of the factors that influence environmental behavior and public support for climate policies. It will also review methodological questions relevant for (online) surveys. In the integrated exercises students will be trained to implement online surveys and experiments. Students will be assigned to groups and conduct their own online survey and investigate factors that influence pro-environmental behavior and the support for climate policies.

**Intended Learning Outcomes:**
After attending the module, students will understand current topics in the psychology and economics of climate change. They are capable of applying online surveys to analyze the support or rejection towards climate policies and they can reference the relevant empirical evidence. Students can analyze the collected data with the appropriate statistical models. Students learn how to present scientific results in the public. In addition, students learn to write a term paper according to scientific standards.

**Teaching and Learning Methods:**
The lecture will be mostly done by presentations. In addition, articles from newspapers and journals are integrated into the lectures. Together with the lecturer, students will study the content and methods of the academic papers. In the exercises, the students themselves conduct an online survey and analyze the collected data. The results of the online survey are then presented and discussed individually and / or in groups from different perspectives by the students. Students will reproduce what has been learned in a written work.

**Media:**
Presentations, Articles

**Reading List:**
Drews, S., & Van den Bergh, J. C. (2016). What explains public support for climate policies? A review of empirical and experimental studies. Climate policy, 16(7), 855-876.
Bergquist, M., Nilsson, A., Harring, N., & Jagers, S. C. (2022). Meta-analyses of fifteen determinants of public opinion about climate change taxes and laws. Nature Climate Change, 12(3), 235-240.

**Responsible for Module:**
Pondorfer, Andreas; Prof. Dr.sc.pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Environmental Behavior and Support for Climate Policies (Vorlesung mit integrierten Übungen, 4 SWS)
Pondorfer A [L], Pondorfer A, Hoch G
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0239: Advanced Seminar in Environmental and Development Economics | Advanced Seminar in Environmental and Development Economics

Version of module description: Gültig ab winterterm 2024/25

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The examination consists of a written seminar paper proving the ability of writing a scientific paper in the context of environmental and development economics and an oral presentation with discussion. The paper includes individual data analysis using econometric models as well as the discussion of the results and methods used. The seminar paper should cover 15-20 pages and is written in the style of a peer reviewed journal article. At the end of the module students present their work in a 30 minutes presentation. Weighting: Seminar paper 2, Presentation 1

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Advanced Development Economics, Advanced Environmental Economics, Advanced Empirical Research Methods

**Content:**
This advanced seminar focuses on recent developments in environmental and development economics. After being introduced to adequate research themes, students explore the academic literature on a chosen topic and develop their own research question. The topics are typically related to the assessment of interventions regarding determinants and causal relationships theoretically and empirically. Potential topics are:
- entrepreneurship
- agriculture
- migration - Environmental impacts of economic actions

**Intended Learning Outcomes:**
The objective of the module is to equip the participants with the necessary skill and tools for a successful master thesis project in the field of environmental and development economics.

**Teaching and Learning Methods:**
In an introductory session, the theme of the seminar is introduced and elaborated in detail. The introduction will also introduce the relevant literature in environmental and development economics. Based on the introduction, students will develop their own research question and decide on the adequate research methods. During the term students have to reach different milestones (e.g., choose a topic, choose a research method, collect data, outline their paper, write the paper, present the results) on specific dates. Following the submission of the seminar paper, students will present and discuss their research question and findings. During all stages of the seminar students will be assisted by the lecturer(s).

**Media:**
Research papers; presentation slides

**Reading List:**
Valerie Matarese (2013). Using strategic, critical reading of research papers to teach scientific writing: the reading–research–writing continuum, Editor(s): Valerie Matarese (2013). In Chandos Information Professional Series, Supporting Research Writing, Chandos Publishing,Pages 73-89. https://doi.org/10.1016/B978-1-84334-666-1.50005-9.)

Yongyan Li, Margaret Cargill, Xin Gao, Xiaoqing Wang, Patrick O'Connor (2019). A scientist in interdisciplinary team-teaching in an English for Research Publication Purposes classroom: Beyond a “cameo role”,
Journal of English for Academic Purposes, Volume 40, Pages 129-140. https://doi.org/10.1016/j.jeap.2019.06.005.

Yongyan Li, John Flowerdew (2020). Teaching English for Research Publication Purposes (ERPP): A review of language teachers’ pedagogical initiatives, English for Specific Purposes, Volume 59, Pages 29-41. https://doi.org/10.1016/j.esp.2020.03.002.

**Responsible for Module:**
Faße, Anja; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Seminar in Environmental and Development Economics (Seminar, 4 SWS)
Faße A [L], Faße A
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0241: Excursion Circular Economy & Sustainability | Excursion Circular Economy & Sustainability

Version of module description: Gültig ab summerterm 2023

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>irregularly |
| **Credits:***<br>3 | **Total Hours:** | **Self-study Hours:** | **Contact Hours:** |

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

**Description of Examination Method:**
Passed/not passed: Participation in total excursion; 10-15 min preparatory keynote; 1-2 written pages reflection after excursion

**Repeat Examination:**

**(Recommended) Prerequisites:**
Participation in the excursion is linked to registration and participation in the "Advanced Seminar in Circular Economy and Sustainability Management" or to use the research results of the excursion in a Master Thesis (to be discussed prior with the module responsible)

**Content:**
12-day excursion to Ghana to carry out the necessary scientific works for the seminar or the master thesis with student keynotes on cultural topics as preparation and written reflection after arrival. Visiting hot spots of ecological challenges and stakeholders actively contributing towards more sustainable behavior. Engaging with locals for on-site research.

**Intended Learning Outcomes:**
The excursion aims to support the profile building and the acquisition of scientific and social competencies. The main focus is to create and gain first-hand insights on Circular Economy topics in Ghana and to counteract the habit of talking from a Northern perspective about the challenges of the Global South. By participating in the excursion, students should be enabled to acquire in-depth knowledge on the seminar topics offered within the "Circular Economy in the Global South, the case of Ghana" on-site and firsthand.
The students will get insights into the diverse and rich Ghanaian culture, which will further enhance their understanding of global Circular Economy challenges.

By performing on-site field research to collect primary data, they will develop solution approaches to closing resource loops and establish contact with locals.

**Teaching and Learning Methods:**
Excursion: after a kick-off session and several introductory lectures, the students will carry out literature research on cultural and travel-relevant aspects related to Ghana. They summarize their findings in an oral keynote. In this process, they are supervised, receive materials, thematic introductions, and continuous feedback. After returning from the excursion, they will reflect upon their learnings in written form.

Teaching/learning methods:
- Kick-off session
- Lectures
- Individual work and feedback
- Presentation
- On-site visits
- Workshops
- Exchange with locals

**Media:**
Digital projector, board, flipchart, online contents, recent scientific journal publications

**Reading List:**
Topic related reading, especially articles in international peer reviewed journals, will be provided in the kick-off meeting and lectures of the module.

**Responsible for Module:**
Magnus Fröhling

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

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

## Module Description

### CS0244: Inventory and Transportation Management | Inventory and Transportation Management

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Written exam: 60 minutes written exam on presentation, recommended readings, and case studies

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Bachelor Business administration; advanced knowledge of Mathematics, Statistics and Operations Research

**Content:**
The course covers decision-oriented aspects of logistics and discusses basic concepts, models, and methods for inventory management and transportation planning in supply chains. This course content provides the foundation for a critical examination of logistics systems from a theoretical and practical perspective.

Part A: Introduction
▪ Terminological Issues of Logistics Management
▪ Principles of Logistics Management

Part B: Inventory Management
▪ Basics of Inventory Management
▪ Lot Sizing
▪ Safety Stock
▪ Work-in-Process

Part C: Transportation Management

▪ Basic Methods for Transport Optimization
▪ Transportation Planning
▪ Packaging
▪ Shortest Rout Problems
▪ Traveling Salesman and Vehicle Routing

**Intended Learning Outcomes:**
The students:
- know the conceptual structure of inventory management and transportation planning and understand basic concepts, models, and methods that are applied in industry and logistics applications
- gain experience in the logistics using prevalent decision models, software systems and understand scope and limitations in supporting practical decision situations.
- hone their skills with respect to modeling and solving decision problems in logistics management.

**Teaching and Learning Methods:**
Lecture (theory), tutorials with group work and presentation

**Media:**
Seminaristic delivery using beamer, overhead projector, flipchart

**Reading List:**
Chopra/Meindl (2009): Supply Chain Management: Strategy, Planning, and Operation, Global Edition
Ghiani, G., Laporte, G., Musmanno R. (2013), Introduction to Logistics Systems Management, 2. edition, Wiley
Günther, H.O., Tempelmeier, H. (2020), Supply Chain Analytics
Silver, E. A., Pyke, D. F. und R. Peterson, Inventory Management and Production Planning and Scheduling, 3. edition, New York (Wiley) 1998.

**Responsible for Module:**
Alexander Hübner

**Courses (Type of course, Weekly hours per semester), Instructor:**
Inventory and Transportation Management (Lecture) (Vorlesung, 2 SWS)
Hübner A [L], Hübner A

Inventory and Transportation Management (Exercise) (Übung, 2 SWS)
Hübner A [L], Riesenegger L
For further information in this module, please click campus.tum.de or here.

## Module Description

### CS0274: Economic History and Comparative Development | Economic History and Comparative Development

*The roots of wealth and inequality across the globe*

Version of module description: Gültig ab winterterm 2022/23

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

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

**Description of Examination Method:**
Achievement of desired learning objectives shall be verified in a term paper (max. 10 pages) and an oral presentation in a group. The students will provide an overview of their chosen topic and present the findings in the context of the relevant literature in a group presentation (each student has to present 10 minutes). The oral presentation shall be assessed according to content and rhetoric aspects. The term paper is written individually and summarizes the relevant literature, empirical method, data, and key findings. Weighting: Term paper 2, Presentation 1.

**Repeat Examination:**

**(Recommended) Prerequisites:**
Advanced Development Economics

**Content:**
Why, when and how did the world become rich/poor? Research of contemporary economic development has often neglected historical factors in explaining differences in inequality and wealth. The study of the past was usually delegated to the field of economic history, and connections between historical factors and present-day economic outcomes were seldom made. This course will cover the rapidly growing body of research within economics that takes a historical perspective into account.

The course uses a historical and comparative approach to understand the evolution and development of societies. In particular, we will examine research that asks whether differences in economic development, wealth and inequality today have historical roots. In addition, we will study different mechanisms and channels through which history matters. Particular attention will be paid to the role of institutions, geography and culture in explaining historical persistence. The course also covers important empirical methods to identify the causal effects of past historical events (e.g., the different types of colonial institutions) on current outcomes (e.g., GDP per capita in 2010).

While the material covered in the course is grounded in the field of economic history, there is a natural overlap with other fields in economics, particularly development economics, political economy, and cultural economics, as well as overlap with other disciplines, such as history, psychology, political science, anthropology, archaeology, and geography.

**Intended Learning Outcomes:**
After attending the module, students will understand what historical factors influenced economic development and how persistent these factors are, i.e., how they still affect economic outcomes across countries today. Students can apply theories, concepts, and analytical techniques associated with economic history and microeconomics. Students will be also capable of using empirical methods to analyze persistent effects of historical data. In addition, students will learn to present scientific results and write a term paper according to scientific standards.

**Teaching and Learning Methods:**
The lecture will be mostly done by presentations (PowerPoint). In addition, articles from newspapers and journals are integrated into the lectures. Together with the lecturer, students will study the content and methods of the academic papers. In the exercises, the students themselves choose a topic related to economic history and comparative development. The findings of their analysis will be presented and discussed individually and / or in groups from different perspectives by the students. Students will reproduce what has been learned in a written work (term paper).

**Media:**
Presentations, articles

**Reading List:**
- Oded Galor (2022), The Journey of Humanity. Random House.
- Joseph Henrich (2020), The Weirdest People in the World. Penguin Random House.
- Alberto Bisin and Giovanni Federico (2021), The Handbook of Historical Economics, Academic Press
- Bibliography of scientific publications

**Responsible for Module:**
Pondorfer, Andreas; Prof. Dr.sc.pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Economic History and Comparative Development (Vorlesung mit integrierten Übungen, 4 SWS)
Pondorfer A [L], Pondorfer A, Ahmed M
For further information in this module, please click campus.tum.de or here.

## Module Description

# CS0275: Economic Valuation of Consumer and Environmental (non-market) Goods | Economic Valuation of Consumer and Environmental (non-market) Goods

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
The examination will be given in the form of a written examination as well as students' presentations.
The students should be able to evaluate and use the taught methods of market analysis. Using case studies, students must discuss various questions related to the theoretical background of non market goods and consumer goods. Besides that, the students have to answer questions about the used statistical programs and data analysis. Duration of written examination: 60 minutes. The proportion of the written examination is 50% of the total grade.

The students' presentations aims to present the scientific methods and results of a student project elaborated during the semester. The students present individually or in groups the elaborated results and discuss them with their colleagues and lecturers. Powerpoint and presentation equipment are allowed for the presentations. Students must give an intermediate presentation (duration: 10 minutes) and a final presentation (duration: 20 minutes). Students will only be admitted to the final presentation if they have successfully completed the interim presentation. The proportion of the presentations is 50% of the total grade.

Both parts of the grade (written examination and presentation) must be passed in order to successfully complete the module.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Prerequisites for the successful participation is knowledge about,
- basic knowledge about non-market goods

- basics of multivariate analysis methods
-basics in empirical data collection

**Content:**
This course aims to explain the valuation of consumer goods and non-market goods.

In the first part of the lecture, students will learn basic aspects of consumer goods and of environmental goods.
Consumer goods: The students get to know different types of consumer goods (e.g. durable goods, nondurable goods, services) and how they can be characterized.
Non-market goods: These goods provide many services, like clean air, carbon capturing or protection against floods or erosion. These ecosystem services are not traded on a market and accordingly do not have an observable market price. To show the value of environmental services, e.g. to evaluate policy measures that enhance or reduce ecosystem services, we need approaches for nevertheless quantifying the value of environmental services.

Based on the first part, the second part of the course introduces and discusses different methods for (non-) market valuation of consumer goods and environmental services. Students will learn the theoretical background of a Choice Based Conjoint Analysis as well as its application by means of examples. The analysis of sample data will also be discussed and practiced with the help of appropriate software (e.g. Sawthooth).

In the third part of the module, students have to apply the methods and tools they have learned. The students receive already collected data (in the field of consumer goods) or implement their own online survey using a Choice Based Conjoint approach (in the field of non-market goods). Students have to develop specific research questions based on the given data or non-market good scenario using also information provided in scientific literature. After that, students must analyze data using a Choice-Based Conjoint analysis to answer their research questions. In a final step, students must present their findings.

**Intended Learning Outcomes:**
After attending the module, students can characterize current topics and methods in the evaluation of consumer and environmental (non-market) goods. Students will learn to analyze and use different concepts for valuing consumer goods and environmental services as well as the concepts' strengths and weaknesses. Further, they will learn how to collect, analyze, and evaluate data by using choice analytics survey software as well as to interpret the results.

**Teaching and Learning Methods:**
The lecture will be mostly done by presentations. In addition, articles from newspapers and journals are integrated into the lectures. Together with the lecturer, students will study the content and methods of the academic papers.
In the project work, the students themselves either analyze collected data (which will be provided to the students) or implement an online survey for non-market goods and analyze the data

collected in this survey. The results of the evaluation are then presented and discussed individually and / or in groups from different perspectives by the students.

**Media:**
Presentations, slide scripts, articles

**Reading List:**
- Sawthooth manuels
- Hair, J.F., Black, W.D., Babin, B.J., & Anderson, R.E. (2013): Multivariate Data Analysis, Pearson, Upper Saddle River
- Champ, P.A., Boyle, K. J., and & Brown T. C., (2017): A Primer on Nonmarket Valuation, Springer

**Responsible for Module:**
Thomas Decker (thomas.anton.decker@mytum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**
Economic Valuation of Consumer and Environmental (non-market) Goods (Vorlesung mit integrierten Übungen, 4 SWS)
Pondorfer A [L], Pondorfer A, Decker T
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0277: Sustainability and Risk Management | Sustainability and Risk Management

Version of module description: Gültig ab winterterm 2022/23

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

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

**Description of Examination Method:**
Achievement of desired learning objectives shall be verified in a term paper (max. 15 pages) and an oral presentation in a group. The students will provide an overview of their chosen topic and present the findings in the context of the relevant literature in a group presentation (each student has to present 10 minutes). The oral presentation shall be assessed according to content and rhetoric aspects. The term paper is written individually and summarizes the relevant literature, empirical method, data, and key findings. Weighting: Term paper 2, Presentation 1.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
In the light of recent studies on climate change, economies face major challenges in achieving climate targets and halting global warming. Nowadays climate risks are a central challenge for the real and financial sector, which is why all companies and financial intermediaries must take climate risks into account in their risk management. The European Union sees the reorientation of the financial industry towards sustainable finance as a central bridge to the implementation of the Paris climate targets. In view of these challenges and in order to mitigate ESG (Environment, Social and Governance) risks, including climate risks, this course will examine the way in which business and society make an assessment of, control and transfer risks.
This course will provide an understanding and application of quantitative and qualitative methods of analyzing and managing risk within organizations. In addition, we will study different multiple risk management tools to make high quality decisions for balancing corporate risk and reward tradeoffs.

Financial risk topics will include the examination of derivative application uses for hedging risk, measuring Value at Risk and exploring external impacts such as market, credit and systemic risks.
Enterprise risk topics will include constructing frameworks for managing strategic, operational and outsourcing of business risks. We will examine ways to assess and measure risk along with organizing corporate governance policies.

**Intended Learning Outcomes:**
After attending the module, students will be prepared to function in a business environment, developing an awareness of the challenges, the tools, and the process of designing and implementing a sustainability and risk management program. Students can apply theories, concepts, and analytical techniques associated with sustainability and risk management. Students will be also capable of using empirical methods to analyze and evaluate risks. Moreover, students will develop the ability to identify strengths and weaknesses of approaches to solutions from fact-based analysis and to synthesise them creatively into improved solutions. In addition, students will learn to present scientific results and write a term paper according to scientific standards.

**Teaching and Learning Methods:**
The lecture will be mostly done by presentations (PowerPoint). In addition, articles from newspapers and journals are integrated into the lectures. Together with the lecturer, students will study the content and methods of the academic papers. In the exercises, the students themselves choose a topic related to sustainability and risk management. The findings of their analysis will be presented and discussed individually and / or in groups from different perspectives by the students. Students will reproduce what has been learned in a written work (term paper).

**Media:**

**Reading List:**
• Gardoni (Ed.) (2017). Risk and Reliability Analysis: Theory and Applications. Springer International Publishing.
• Tamas Vasvari (2015). Risk, Risk perception, risk management – a Rewiew of the Literature. Pablic finance Quarterly. State Audit Office of Hungary, vol. 60(1).
• A Risk Practitioners Guide to ISO 31000: 2018. (2018). Review of the 2018 version of the ISO 31000 risk management guidelines and commentary on the use of this standard by risk professionals. Institute of Risk Management. A company limited by guarantee. Registered in England number 2009507
• Borghesi A., Gaudenzi, B. (2013). Risk Management, Perspectives in Business Culture, Springer-Verlag Italia
• Peter Moles (2016). Management Sources of Financial Risk and Risk Assessment. Edinburgh Business School Heriot-Watt University Edinburgh
• Bessis,J. (2015) Risk Management in Banking 4th ed. (UK)
• Crouhy M, D Galai and R Mark (2009) Risk Management, New York: McGraw Hill.

• Greuning,H., Bratanovic, S. (2013) Analysing Banking Risks: A Framework for Assessing Corporate Governance and Risk Management, 4th ed. The World Bank
• Mechler, R. et al (eds.) (2019) Loss and Damage from Climate Change : Concepts, Methods and Policy Options, Cham
• Shin, Hyun Song (2019) Risk and Liquidity, Claredon Lectures in Finance
• Selected publications from Basel Committee on Banking Supervision, ESAs, EPCC, WMO.
• Aagaard A. (2019) Sustainable Business Models: Innovation, Implementation and Success. Palgrave Macmillan.
• Leleux, B. & van der Kaaij, J. (2019) Winning sustainability Strategies (Finding Purpose, Driving Innovation and Executing Change). Palgrave Macmillan
• Schoenmaker, D., & Schramade, W. (2019). Principles of Sustainable Finance. New York: Oxford University Press.
• Bielenberg, A., Kerlin, M., Oppenheim, J., & Roberts, M. (2016). Financing change: How to mobilize private sector financing for sustainable infrastructure. Chicago: McKinsey Center for Business and Environment.
• European Political Strategy Centre. (2017). Financing Sustainability, Triggering Investments for the Clean Economy. Brussels: European Commission.
• High-Level Expert Group on Sustainable Finance. (2018). Financing a Sustainable European Economy-Final Report. Brussels: European Commission.
• Filippi M.E. (2022). A role for municipal governments in leveraging transformative change for urban disaster risk management: The experience of Santa Fe, Argentina, with urban flood risk,Climate Risk Management, Volume 35.
• Bo Chen, Liuxin Chu (2022). Decoupling the double jeopardy of climate risk and fiscal risk: A perspective of infrastructure investment, Climate Risk Management, Volume 37
• Henry Ngenyam Bang, Nicholas Church Burton (2021). Contemporary flood risk perceptions in England: Implications for flood risk management foresight, Climate Risk Management, Volume 32

**Responsible for Module:**
Pondorfer, Andreas; Prof. Dr.sc.pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Sustainability and Risk Management (Vorlesung mit integrierten Übungen, 4 SWS)
Pondorfer A [L], Shkola V
For further information in this module, please click campus.tum.de or here.

## Module Description

# CS0278: Sustainability and Innovation Management in an Industrial Context | Sustainability and Innovation Management in an Industrial Context

*The transformation of ESG into value and growth*

Version of module description: Gültig ab summerterm 2023

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

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

**Description of Examination Method:**
Lecture: Written exam (90 minutes): Students have to analyse, assess and discuss (simplified) sustainability / ESG-driven innovation frameworks, processes and product case studies on a local, regional, national and global level. They determine starting points for an optimisation of these concepts and apply them to real-life use cases. Thereby, they have to take different points of view. In doing so, the students have to prove their ability to use the right vocabulary, and their knowledge on the motivation and key figures of sustainably innovation.
Seminar: Intermediate and final team presentations: Student teams have to analyse, assess, discuss and select a certain sustainability/ESG-driven idea/proposal they would like to transform into reality step-by-step.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
The module covers the following topics:

• The nature of innovation in its inherent key ingredient: Uncertainty.
• The process of industrial innovation and its various stages
• Tools to manage each stage of the innovation process professionally to reduce uncertainty & risk and improve the performance and results of each stage
• The different levels of industrial innovation and their interdependencies

• The creation and management of innovation portfolios, innovation roadmaps, and innovation projects
• The concept of ESG in sustainability management and various ESG criterions
• Legal and policy frameworks regarding sustainability/ESG such as the European Green Deal
• The impact of sustainability/ESG on performance, shareholder value, and investment decisions
• The introduction of various theoretical frameworks regarding the development of human value systems related to sustainability/ESG
• The introduction and discussion of various broader sustainability/ESG-driven innovation frameworks such as circular economy, sharing economy, sustainable urban mobility, bioeconomy, carbon to value/decarbonization, sustainable energy systems etc.
• Identifying innovation potentials regarding sustainability/ESG inside innovation frameworks, business models, products, systems or components and tools to address these potentials to create value
• The creation and management of sustainability/ESG-related innovation portfolios, road maps and projects
• An interdisciplinary and coached real-life simulation in teams on selected sustainability/ESG-driven innovation ideas/proposals to apply and train the gained knowledge on how to identify promising projects and transform them into successful marketable products.

**Intended Learning Outcomes:**
Students remember and understand the nature and different stages of industrial innovation and they understand how the transformation from ideas to products can be managed professionally through tools such as innovation portfolios, innovation roadmaps and innovation project management. They understand the several levels of innovations and the strong interdependencies between these levels. They can apply their knowledge to analyse, evaluate the composition of any given business model or product (concept) to identify innovation potentials and to create, analyse, propose and prioritize ideas/proposals that would address these innovation potentials in a way that value can be created.
Students remember and understand the legal and policy frameworks related to sustainability/ESG. They understand the concept of ESG in the context of sustainability management, the various sustainability/ESG criterions and their impact on business performance, shareholder value and investments decisions. They gain an understanding into the development of human value systems and understand why sustainability is a key foundation for the next innovation super cycle that will drive economy and development throughout the next decades.
Based on a deep understanding of the nature of innovation and sustainability/ESG students can evaluate and analyse broader ESG-innovation frameworks such as circular economy, sharing economy, bio economy, sustainable urban mobility, sustainable housing, carbon-to-value/decarbonisation etc. and their practical implications.
Students will be able to apply their knowledge and to create and manage ESG-related innovation portfolios, roadmaps and innovation projects inside existing or new organisations such as start-ups

**Teaching and Learning Methods:**
Format: lecture and exercises to introduce the content, to repeat and deepen the understanding as well as practice individually and in groups.

Teaching / learning methods:
- Media-assisted presentations
- Group work / case studies / reading of scientific publications with presentation
- Individual assignments and presentation to consolidate/repeat the learned contents
- Plenary discussions to reflect the lecture contents
- Group work on the transformation sustainability/ESG-driven innovation ideas/proposals
- Design Thinking
- Teams and individual coaching sessions
- Project pitches (Final and intermediary)

**Media:**
Digital projector, board, flipchart, online contents, case studies

**Reading List:**
Recommended reading:

• Hauschildt, Jürgen; Salomo, Sören et al: Innovationsmanagement (2016/2023), Vahlen
• Dodgson, Mark; Gann, David: The Oxford Handbook of Innovation Management (2015), Oxford University Press
• Thewes, Rüdiger: Let´s Change a Running System: Transformationswege in eine Nachhaltige Wirtschaft (2021), Tredition
• Christensen, Clayton: The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail (2016), Harvard Business Review Press
• Allianz Global Investors (2010): The sixth kontratieff – long waves of prosperity: https://www.allianz.com/content/dam/onemarketing/azcom/Allianz_com/migration/media/press/document/other/kondratieff_en.pdf
• Mathews, John A.: Greening of Capitalism: How Asia Is Driving the Next Great Transformation (2014), Stanford University Press
• Nefiodow, Leo: The Sixth Kondratieff: A New Long Wave in the Global Economy (2017), CreateSpace Independent Publishing Platform
• Beck, Don Edward; Cowans, Christopher C. : Spiral Dynamics - Leadership, Werte und Wandel: Eine Landkarte für Business und Gesellschaft im 21. Jahrhundert (2020), Kamphausen Media
• Circularity Gap Report Global (2022); https://www.circularity-gap.world/2022
• Osterwalder, Alexander; Pigneur, Yves: Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers (Strategyzer) (2010), Wiley
• Lewrick, Michael : Design Thinking for Business Growth: How to Design and Scale Business Models and Business Ecosystems (2022), Wiley
• https://www.europarl.europa.eu/news/en/headlines/society/20200618STO81513/green-deal-key-to-a-climate-neutral-and-sustainable-eu
• Deloitte: Fit for 55: Maßnahmenpaket der EU zur Umsetzung des Green Deal (2022), Deloitte
• McKinsey: The green business building opportunity (2022), McKinsey
• Peter Lacy, Jessica Long: The circular Economy Handbook: Realizing the Circular Advantage (2020), Wesley Spindler

• UNITED NATIONS SDGS: https://www.undp.org/sustainable-development-goals?utm_source=EN&utm_medium=GSR&utm_content=US_UNDP_PaidSearch_Brand_English&utm_campaign=C
gIVhuJ3Ch3pVQtFEAAYAyAAEgLnGvD_BwE
• EUROPEAN GREEN DEAL: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
• Bardi, Ugo: LIMITS TO GROWTH REVISTED (2011), Springer
• Dixson-Decleve Sandrine; Gaffney, Owen, et al.:  EARTH FOR ALL: A Survival Guide for Humanity (2022), New Society Publishers

**Responsible for Module:**
Prof. Magnus Fröhling

**Courses (Type of course, Weekly hours per semester), Instructor:**
Sustainability and Innovation Management in an Industrial Context (Vorlesung, 2 SWS)
Fröhling M [L], Seidel M
For further information in this module, please click campus.tum.de or here.

## Module Description

# CS0279: International Markets of Renewable Energies | International Markets of Renewable Energies

Version of module description: Gültig ab summerterm 2023

| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
|---|---|---|---|
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
The examination will be given in the form of a students' presentation. Using case studies of renewable energy applications in selected countries, students must elaborate and discuss relevant topics related to the challenges in the provision of energy. The results must be placed in a country-specific context of the selected renewable energy. The students' presentation aims to present the results of this student project elaborated during the semester. The students present individually or in groups (max. 5 members per group) their research question, methodology and results and discuss them with their colleagues and lecturers. Duration of presentation: 20 minutes. In addition, every student must submit a short, individual elaboration on the topic (5 pages). To successfully pass the module, the student must successfully complete both parts (presentation (50%) and project report (50%)).

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basic knowledge about functioning of (energy) markets

**Content:**
The content of the lecture is structured as follows:
- Global challenges in energy supply and demand
- Political activities to foster the use of renewable energies
- Global markets of fossil fuels
- Global markets for biomass and biogenic by-products
- Worldwide markets for use of renewable energies
- Situation and development of selected (renewable) energy markets in specific countries or regions (projectwork of the students)

**Intended Learning Outcomes:**
After attending the module, students can characterize different energy markets in the world. These markets will be divided into markets for fossile fuels (e.g. crude oil, natural gas, coal), and in markets for regenerative energy production (e.g. wind, hydro, solar energy, biomass, biogenic by-products). Based on this knowledge, the students can classify, analyze and interpret the results found during the individual group work in a country-specific context. Students understand what influences the selected energy markets and why the markets developed as they did.

**Teaching and Learning Methods:**
The lecture will be mostly done by presentations. In addition, articles from newspapers, homepages and journals are integrated into the lectures.
In the seminar, the students must investigate selected (renewable) energy markets of a specific country or region doing a scientific literature review on their own. In the elaboration of their project work, students are supported by several feedback meetings and discussions with the instructor.

**Media:**
Presentations, slide scripts, articles

**Reading List:**
Word energy outlook of the IEA

**Responsible for Module:**
Dr. Decker, Thomas

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

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

# Module Description

## CS0301: Advanced Practical Research Experience | Advanced Practical Research Experience

Version of module description: Gültig ab summerterm 2024

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

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. The student works on a specific problem set. The student runs through several project stages: problem definition, division of work/tasks, decision-making processes, and realization. Throughout this process, the student shows that she/he can develop appropriate strategies to cope with the set of problems. She/he shows the ability able to compose the state of research. In addition, she/he demonstrates the ability to develop their own specific approach for a solution based on scientific knowledge as well as methodical skills.
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:**
Advanced knowledge in concepts of Management and Business Administration
Operations Research (CS0098)
Advanced Modelling and Optimization (CS0170)
Advanced Seminar in Supply and Value Chain Management (CS0112 or CS0090)

**Content:**
The research study consists of a specific problem statement or challenge. This challenge may have a research related or practical character. The research project and its findings regarding the outlined problem set are based on students' academic knowledge gained through their study programs. Examples of topics covered in the context of a include (non-exhaustive list) for example

analyzing potential sales volumes with data mining techniques, identifying potential optimization actions or developing algorithms for certain business problems.

**Intended Learning Outcomes:**
After successful participation in the module, students are able to work on sophisticated research projects in a systematic and academic manner. Students are able to complete a research project in particular in identification research gaps, developing research questions, selecting appropriate research methods and apply them to actual research problem. Students obtain capabilities to deepen and apply theoretical concepts to the identified problem set and develop their analytical solution finding skills. Students become able to manage resources, and deadlines through timely submission of the enumerated tasks in stages throughout their research projects.

**Teaching and Learning Methods:**
The development of the solution of the research question encourages the students to deal soundly with an academic subject based on their previously acquired academic knowledge. The project may happen at the premises of a respective company/institution or from a remote location. Participants are able to communicate the evolvement of the project by composing a project report and preparing a presentation of their solutions to the supervisors. With regards to content, the research study takes an approximate time of 6-8 weeks.

**Media:**
literature, presentations

**Reading List:**
Project Management Institute (2013): A Guide to the Project Management Body of Knowledge (PMBOK® Guide) - Fifth Edition
Further literature based on the specific topic

**Responsible for Module:**
Hübner, Alexander; Prof. Dr. rer. pol.

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

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

# Module Description

## CS0305: Research Excursion Master | Research Excursion Master

Version of module description: Gültig ab summerterm 2024

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>irregularly |
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>60 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
Passed/not passed:
The module is passed when the students deliver a learning portfolio consisting of the following elements::
1. 2 written pages or 20’ presentation on preparatory work for the excursion. The form and the due date will be specified in the kick-off session.
2. At least two topical contributions to the excursion (topical input, interviews, questions on presentations and during site visits, discussion contributions;
3. 5-10 PPT slides reflecting the findings based on a case study visited during the excursion. The due date will be specified in the kick-off session;
4. Final report of case studies and results of the workshop;

All four elements of the learning portfolio have to be delivered to pass the module.

**Repeat Examination:**

**(Recommended) Prerequisites:**
Prerequisites may be defined by the professors / lecturers offering the excursion, dependent on the chosen destination / topic. They will be announced with the announcement of the excursion 1 month before the start of lectures in the semester in which the excursion is offered, at the latest.

**Content:**
The research excursion deals with individual topics from modules and / or the study programs for which it is designed. On an individual basis, professors and lecturerers from these modules / study programs offer the research excursion to a topic or place of their choice.

A bullet point list with typically 10-12 entries will be provided by the professors and lecturers with the announcement of the research excursion 1 month before the start of lectures in the semester in which the excursion is offered, at the latest.

After the excursion the results of the applied methodologies are presented and discussed in a workshop. Key findings and the results of the workshop are included in a final excursion report by the students.

**Intended Learning Outcomes:**
The excursion aims to support the scientific profile building of students and the acquisition of scientific, practical and social competencies and the application to case studies visited during the excursion. It supports the competence acquisition in other modules and / or the study programs in general. The students get practical insights into the topical field of the research excursion, deepen their comptencies in this field regarding ongoing research and apply their competencies to real case studies in practice.

In particular, the intended learning outcomes are the following:
- Select relevant scientific and practical information and recall it for for visits of organizations, cities and talks with experts and stakeholders,
- Prepare questions regarding the state-of-knowledge, open research questions and practical relevance and discuss these with fellow students,
- Discuss research and practical knowledge with stakeholders,
- Recognize the implementation of research and practical knowledge in the organisations / sites visited,
- Reflect on the state of implementation of theoretical knowledge in practice,
- Discuss with fellow students and supervisors gained insights and compare it with their expectations,
- Perform structured interviews and talks with experts and stakeholders in practice
- Apply methodologies from theoretical lectures and exercises on practical organizations

**Teaching and Learning Methods:**
The research excursion consists typically of the following elements (teaching, learning and application of methods):
- Kick-off session: To achieve a good get-to-know, brief the students about the module contents, course and required performance an interactive in-presence workshop will be carried out. This covers presentations, and interactive elements such as role games etc.
- Individual work and feedback: In order to prepare for the on-site visits the students carry out own literature research on the excursion topics. To document their learning progress and to be able to share the results they summarize their findings in written form. A presentation of the contents in front of the fellow students is an optional element. In this process, they are supervised, receive materials and continuous feedback.
- On-site visits: 3-5 day research trip with site-visits, presentations, discussions with stakeholders, interviews of experts etc. This part will be specified in the specific program of the research

excursion and can due to the variety of possible destinations and topics not be specified further at this point.
- Individual work: the students will reflect their learnings in written form,
- Workshop: the students will present and discuss their findings in a workshop to gain practical experience for their future working conditions and formulate a final excursion report.

**Media:**
Digital projector, board, flipchart, online contents, recent scientific journal publications, equipment and utilities demonstrating production processes in practice

**Reading List:**
Topic related reading, especially articles in international peer reviewed journals, will be provided during the course of the module.

**Responsible for Module:**
Prof. Cordt Zollfrank Prof. Hubert Röder Prof. Magnus Fröhling

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

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

# Module Description

## CS0315: Business Planning and Valuation | Business Planning and Valuation

Version of module description: Gültig ab winterterm 2024/25

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

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

**Description of Examination Method:**
Achievement of desired learning objectives shall be verified in a written final exam and an oral presetation. In the oral test, the foundations of business analysis and planning are presented by the students based on a case example. In the written examination the students calculate key indicators of business analysis and business plan concepts and evaluate and declare the contents of business plans. This examines whether the students can apply the learned contents of business analysis and planning in their own words. The written final exam shall be integrated into the general assessment by 75% and the oral presentation by 25%.

Type and duration of exam: In writing (60 min) and oral (20 min);

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
none

**Content:**
The "business analysis" lecture includes economic analysis methods based on selected business areas of renewable resources and a case study (e.g. biomass CHP) including the impact of changing business framework.

The "businessplan" exercise provides an introduction to the process of creating a business plan exemplarily by establishing a company. The topics are divided into the following areas:
1. Definition Entrepreneurship
2. Entrepreneurial opportunities and implementation

3. The person of the entrepreneur
4. Innovation and Entrepreurship
5. Business strategy and model
6. Marketing and market orientation
7. Start-up financing
8. Growth and Exit
9. Business Plan

**Intended Learning Outcomes:**
Upon successful completion of this module, the students understand the general framework of business analsyis and planning and are able to understand and apply these methods in practice. Furthermore, students' entrepreneurial thinking is encouraged. In addition, students are able to evaluate existing business plans and to formulate a well structured business plan based on their business ideas.

**Teaching and Learning Methods:**
The module consists of a lecture and an exercise. During the lectures the contents are delivered by presentations and discussions primarily as seminaristic dialogue. The lectures are used to convey the theorectical foundations and include conducting some exercises. The students are inspired to improve the acquired knowledge by studying the suggested literature. In the exercises students apply the acquired knowledge in solving exercises and implementing case studies which also include roll playing. Students deepen their understanding through working in small student groups as well as solving exercises on their own. Team work and role playing supports the training of practical application of the lessons learnt and ability to work in teams.

**Media:**
PowerPoint, script, whiteboard, exercise sheets, reader;

**Reading List:**
KALTSCHMITT, M., STREICHER, W. und A. WIESE (Hrsg.): Erneuerbare Energien. Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. Springer; Auflage: 5. Aufl. 2013.
Quaschnig, V.: Regenerative Energiesysteme: Technologie – Berechnung – Klimaschutz. Carl Hanser Verlag GmbH & Co. KG; 10. Aufl. 2019
Fueglistaller et al. (2012), Entrepreneurship - Modelle - Umsetzung - Perspektiven. Springer Gabler Verlag. Wiesbaden;
Evobis Handbuch Businessplan-Erstellung. www.evobis.de;
Faltin (2008), Kopf schlägt Kapital. Carl Hanser Verlag. München;
Oehlrich (2013), BWL – Eine Einführung am Businessplan-Prozess. Verlag Franz Vahlen München.

**Responsible for Module:**
Röder, Hubert; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Business Planning (Übung, 3 SWS)
Röder H [L], Röder H

Business Analysis (Vorlesung, 1 SWS)
Röder H [L], Röder H
For further information in this module, please click campus.tum.de or here.

## Module Description

# ED160037: Circular Economy Spotlights: Technological Innovations and Sustainable Perspectives of the Circular Economy | Circular Economy Spotlights: Technologische Innovationen und Nachhaltigkeitsperspektiven der Kreislaufwirtschaft

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>German/English | **Duration:**<br>one semester | **Frequency:**<br>irregularly |
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>75 | **Contact Hours:**<br>15 |

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

**Description of Examination Method:**
The module examination is an open book written exam composed of subtasks assessing the knowledge gained for each of the lecture themes as well as 1 reflective component. The tasks make out 80% of the total exam assessment and the reflective component is weighted 20%.

For each of the tasks, 2-3 reflective questions need to be answered. The duration of the exam will be 60 minutes.
• Online Exam: The examination will be conducted through a virtual platform (e.g. Moodle)
• Reflection Component: Students will be required to submit a reflective component consisting of multiple small mandatory reflection tests as part of the examination, providing insights into their holistic understanding and application of Circular Economy concepts. For the reflection component, Moodle will be utilized for reflection tests in the form of a 'Discussion Corner.' The plenary discussion feature on Moodle will serve as a space to reflect on lecture contents, allowing students, especially those who may not be familiar with each other due to the nature of the new module, to exchange perspectives on various insights and their content.
The reflective component will be weighted with 20% and should test the student’s understanding of the interconnectedness of the thematic explorations and reflect on the individual learnings in a broader context of the Circular Economy and its dynamic and evolving field of research.
• Open-Book Approach: The examination will adopt an open-book approach, allowing students to refer to course materials and resources during the assessment.
• Pass/Fail Grading: The examination will be graded on a Pass/Fail basis, emphasizing a holistic assessment of the student's overall comprehension, critical thinking, and new Circular Economy perspectives acquired by the students throughout the course.

A strongly suggested prerequisite for writing the exam is attendance on the lecture days (see Content).

The examination will primarily assess the following learning outcomes:

Comprehensive Understanding:
• Evaluate the student's fundamental understanding of Circular Economy, its principles, and its significance in the sustainability discourse, such as the connection between climate impact and Circular Economy
• Comprehend the diverse disciplinary lenses through which Circular Economy can be examined and the discipline-specific knowledge acquired in dedicated lectures.
• Understand the thematic breadth and complexity of the Circular Economy considering environmental, ecological, economic, and social perspectives.
Reflecting:
• Evaluate the complexity and multifaceted nature of the Circular Economy, considering different perspectives gained through the spotlight lectures.
• Assess the student's grasp of the importance of interdisciplinarity in the context of Circular Economy.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
None Specified

**Content:**
The module aims to offer a foundational understanding of Circular Economy, its thematic breadth and complexity by covering disciplines such as Engineering, Natural Sciences, Economics, Politics, and Management and suggesting a personalized approach. The concept is to provide insights across TUM locations and disciplines through expert-led lecture sessions inspired by existing courses. The module opens doors to a series of sustainability lectures, allowing students to delve into the diverse aspects of Circular Economy across different disciplines. For this, a clustered series of lectures and activities will be offered from different disciplines that allow joining without a specific prerequisite in the field.

Students will gain insights into Circular Economy concepts, including but not limited to covering disciplines such as Engineering, Natural Sciences, Economics, Politics, and Management. Opportunities for engaging with guest speakers are integrated into the portfolio, enriching the learning experience with real-world insights.

A kick-off and onboarding session will be organized to introduce participants to the module. Reflection on the learnings and expectations may be part of this initiation process as well as an ending event on the last day of lectures.

**Intended Learning Outcomes:**
After completion of the Circular Economy Spotlight lectures, the course participants will be able to:

o Understand the concept of the Circular Economy and its foundational principles.
o Explain the difference between the traditional linear economy as opposed to the concept of a Circular Economy.
o Gained specific knowledge and insights into Circular Economy aspects applied in multiple disciplines across TUM Schools and locations, such as within Engineering, Natural Sciences, Economics, Politics, and Management.
o Understand the relevance of interdisciplinarity for Circular Economy.
o Assess and reflect on the Circular Economy from an environmental, economic, and social perspective and understand its complexity and broadness of application in different fields.

**Teaching and Learning Methods:**
The teaching and learning methods for in-person lectures will predominantly rely on the individual speaker styles. As a result, these methods may vary from what is considered typical in different disciplines and may include:
- Media-assisted teacher-centered teaching based on presentations.
- Practical examples from guest lectures, providing insights into the subject matter from an applied perspective.
- Active participation in practical learning, such as - Dismantling and recycling exercises in the CE-lab
- Active participation in question rounds and discussions with the teacher and other students
In addition to the individual contact lectures, introductory sessions on the concept of Circular Economy will be held in a hybrid format, to participate in live, recorded, or online lectures, giving them the flexibility to rewatch the content throughout the entire duration of the module.
In addition, part if the self-study contains:
- reading of scientific publications
- plenary discussion through moodle to reflect on the lecture contents & to consolidate/repeat the learned contents

**Media:**
Kick-off online video, digital projector, board, flipchart, PowerPoints, online content, scientific journal publications
Online Information: e-learning course on moodle

**Reading List:**
An extensive reading list will be provided in the portfolio as preparation for each lecture. For introductory reading, please see the recommended reading below.
• Recommend Reading:
- Baccini, Peter (1991): Metabolism of the Anthroposphere, Springer
- De Angelis, Roberta (2018): Business Models in the Circular Economy: Concepts, Examples and Theory, Palgrave Macmillan

- Kirchherr, Julian & Reike, Denise & Hekkert, M.P.. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling. 127. 221-232. 10.1016/j.resconrec.2017.09.005.
- Wiesmeth, H. (2021): Implementing the circular economy for sustainable development. Elsevier, Amsterdam.
- Denise Reike, Walter J.V. Vermeulen, Sjors Witjes (2018) ,The circular economy: New or Refurbished as CE 3.0? — Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options,Resources, Conservation and Recycling,Volume 135,
- TUM Forum Sustainability – Circular Economy, Reichwald et al. 2022, TUM University Press
- Circular Economy Action Plan – COM (2020), European Commission
- Circular Economy Initiative Deutschland (Hrsg.): Circular Economy Roadmap für Deutschland, *Kadner, S., Kobus, J., Hansen, E., Akinci, S., Elsner, P., Hagelüken, C., Jaeger-Erben, M., Kick, M., Kwade, A., Kühl, C., Müller-Kirschbaum, T., Obeth, D., Schweitzer, K., Stuchtey, M., Vahle, T., Weber, T., Wiedemann, P., Wilts, H., von Wittken, R. acatech/SYSTEMIQ, München/London 2021.DOI: https://doi.org/10.48669/ceid_2021-3

**Responsible for Module:**
Fottner, Johannes; 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

## MGT001459: TUM Climate Ventures | TUM Climate Ventures

Version of module description: Gültig ab winterterm 2024/25

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>135 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
This module's learning objectives are examined via exercises ("Übungsleistung") comprising the three elements outlined below. There is no written exam.

(1) Individual written reflection paper (10%): At the end of each session, you will submit a short reflection paper of 1/2 page (font size 12; double line spacing) highlighting the key learnings of the course and explaining why, how, and where they might influence your project. The individual reflection will show that you can process, synthesize, and prioritize the newly learned knowledge and critically think about and argue for more expansive fields of application beyond those discussed in class.

(2) Group presentations (60%): During the class, there will be three presentations: (1) A pitch in the first weeks of the course (2 minutes), (2) a midterm pitch (10 minutes), and (3) a final pitch (15 minutes). Each pitch has to reflect the content of the course. In the session, you will present a part of your group's climate venture. As each member of the group will present, your individual contribution is clearly identifiable and appraisable. The final group presentation will showcase that you are able to synthesize and present your findings in a comprehensive, precise, and structured way. It will also show that you communicate clearly and perform professionally. The final pitch will be graded.

(3) Group written reporting (30%): As part of a group composed in the first two weeks of the course, you will work on a climate venture project by assessing, analyzing, and designing climate-tech venture related strategies and actions. This assessment will show that you can directly apply the learned frameworks, theories, and concepts to uncover and assess the implications of climate ventures, determine and evaluate suitable climate ventures strategies, prioritize and initiate actions and decisions for their implementation, identify predictors of failure, and propose mitigative steps. It also illustrates that you can collaborate in a team, adopt a leader's perspective, strategize,

and solve problems in an analytical and structured way. The reporting includes the submission of a weekly (1) agenda for office hours meetings, a weekly update of an (2) interview tracking spreadsheet (approximately 50 interviews with experts and potential customers that you will conduct between week 3-13), and (3) the pitch decks of your presentations. An assessment sheet filled in by each group member and handed in at the end of the course will clarify your individual contribution.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
The course is looking for two different skill sets. You should either have advanced entrepreneurial knowledge and experience through courses, practical experience, or advanced programs like Manage&More or CDTM, or you have advanced technological understanding of relevant climate tech applications.

**Content:**
Building climate ventures that have impact can be a very complex and demanding challenge. Often this requires an expanded skillset of how to identify, assess, analyze, design, build, and launch climate-tech ventures, as well as high team effort, and very strong leadership. In addition, dynamic markets, technological uncertainties and grand challenges create additional pressures on novel ventures understanding their impact. This module provides a holistic view of the climate venture process in a real-world project. It introduces you to theories, concepts, and frameworks for climate ventures. Students will gain hands-on experience in the startup process, learning how to identify, assess, analyze, design, build, and launch climate-tech ventures.

Emphasis will be placed on effective collaboration within interdisciplinary teams to tackle real-world climate challenges. The course will help students build a strong climate-tech network and community, providing opportunities for collaboration and support. Students will work on creating new companies aimed at addressing high-impact climate problems, from ideation to market entry.

Exploration of breakthrough technologies and their potential applications in solving global climate issues will be a key component of the course. Students will understand the fundamentals of economic and technical evaluations specific to the climate-tech industry. The course will teach customer-centric approaches to developing climate solutions, emphasizing the importance of understanding and addressing customer needs.

Navigating the regulatory and market landscapes influencing climate-tech ventures will also be covered, helping students understand the broader context of their projects.

**Intended Learning Outcomes:**
Upon successful completion of this module, you will be able to:
Course Learning Goals:

1. Analyze relevant technical, business, political, and social drivers and barriers behind a vexing climate-tech challenge and design a solution as a team to address it.
2. Synthesize insights from research, analysis, and external engagements to compose a compelling value proposition around a new venture.
3. Evaluate and iterate through the potential success of a venture plan that meets the criteria of high impact, white space, unique value proposition, and self-sustainability.

Knowledge objectives:
(1) Explain and apply key concepts, frameworks, and theories related to climate ventures in practice
(2) Uncover and assess the implications of relevant technical, business, political, and environmental drivers and barriers behind climate tech ventures
(3) Determine and evaluate climate venture strategies considering venture-specific and contextual factors through research and external feedback
(4) Prioritize and initiate actions and decisions for implementing climate tech ventures with impact
(5) Identify predictors of failure and propose mitigative steps
Competencies objectives:
(1) Improve analytical, structured problem-solving, synthesis, and prioritization competencies
(2) Enhance team collaboration and leadership competencies
(3) Strengthen communication, presentation, and argumentation skills
(4) Build up critical thinking and strategizing competencies
(5) Perform under a maximised degree of realism in building a venture

**Teaching and Learning Methods:**
The module consists of an introductory session in which the fundamentals of climate ventures will be shared and discussed. In addition, groups will be matched and assembled, and each group will work on a real-world climate-tech venture for which a business case will be jointly developed throughout the course.

In subsequent sessions, module contents will be co-developed by the course participants, the instructor(s), and guest lecturers. To enable building up a solid knowledge fundament, we integrate action-learning elements such as presentations and discussions of course material, interview results, and relevant publications; individual mentoring; and interactions with industry and venture capital guest speakers.

Continuous mentoring on the climate-tech ventures will ensure that the newly acquired knowledge will be directly applied. Groups are asked to gather information on their climate venture cases through approximately 50 interviews.
Hence, a large share of learning will occur through your individual and your group's preparation for the in-class sessions and working on your climate venture projects. Respective instructions and materials to prepare will be given throughout the course.

Through presentations, discussions of intermediate findings, guest lectures, and feedback provided by the instructor(s), mentors, industry experts and venture capitalists, you will be able to share and get an assessment of your progress continuously. The module will end with a group presentation followed by a moderated Q&A and joint reflection exercise.

**Media:**
Presentations, flipchart, whiteboard, digital tools, videos, Zoom (for feedback sessions)

**Reading List:**
Class materials, lecture slides, suggested readings, other materials recommended for each team and guest speaker slides will be posted on Moodle.

**Responsible for Module:**
Tryba, Anne; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
TUM Climate Ventures (MGT001459, englisch) (Seminar, 4 SWS)
Tryba A [L], Eiermann-Hüser L, Lara Vargas L, Reiter S
For further information in this module, please click campus.tum.de or here.

# Electives Engineering and Natural Science | Electives Engineering and Natural Science

## Module Description

### WZ1193: Biogas Technology | Biogastechnologie [BiGA]

Version of module description: Gültig ab summerterm 2024

| Module Level: | Language: | Duration: | Frequency: |
| --- | --- | --- | --- |
| Master | 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:**
Students take a written examination (90 minutes) to demonstrate their knowledge of microbial breakdown processes in the biogas process, as well as their ability to assess influencing factors. They also demonstrate their knowledge of various technologies for using biogas and can explain their respective advantages and disadvantages. Additionally, they demonstrate that they have understood the legal and economic framework conditions  of biogas technology and are able to translate these to case examples. Students also show that they can develop basic concepts of biogas plants.They will answer questions on the topic in their own wording and explain case examples or work out calculations. Multiple-choice questions are also possible.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Required: basic knowledge in biology, especially microbiology, as well as general and organic chemistry, mathematics, physics and thermodynamics of cycles; of advantage: knowledge in agriculture and agricultural engineering

**Content:**
Microbiology of biogas processing, anaerobic substrate breakdown, factors influencing the fermentation process, process management strategies, biogas storage and purification; biogas recovery (e.g. use of a motor for power generation with or without the use of heat or feeding into the gas grid); legal-economic framework conditions; sustainability issues; competition for raw material and acceptance of biogas plants; aspects of biogas plant design.

**Intended Learning Outcomes:**
After successful completion of the module, students are able to develop concepts for biogas generation and recovery in a specific context. Students are aware of microbial breakdown processes in biogas plants and can differentiate between various influencing factors. They are also aware of various processes for the use of biogas and understand their advantages and disadvantages. Students recognize the meaning of biogas technology for sustainable energy supply. Students have a good knowledge of legal and economic framework conditions in the field of biogas generation and they are able to conceptualize basic biogas plants.

**Teaching and Learning Methods:**
Lectures given as presentations, with the help of a blackboard and interactive elements, in particular group work on case examples; optional: excursion to a biogas plant to deepen acquired knowledge in a real-life setting

**Media:**
PowerPoint presentation, slide notes, exercise sheets

**Reading List:**
D. Deublein, A. Steinhauser, Biogas from Waste and Renewable Resources - An Introduction, Wiley-VCH, 2010,  ISBN-13: 978-3-527-32798-0, ISBN-10: 3-527-32798-3

**Responsible for Module:**
Doris Schieder (doris.schieder@tum.de)

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

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

# Module Description

## CS0003: Production of Renewable Fuels | Production of Renewable Fuels

Version of module description: Gültig ab winterterm 2023/24

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The learning results are going to be proven in form of a written exam of 90 Minutes. Along the problem set, it is checked whether the student is able to understand, improve and assess industrial processes for the production of renewable fuels. No aids permitted.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basic knowledge in chemistry, Fundamentals in Thermodynamics (e.g., Grundlagen der Thermodynamik), Fundamentals in Process Engineering (e.g., Introduction to Process Engineering)

**Content:**
Requirements for fuels, linkage of energetic and chemical value chains, fossil fuel production as reference, balancing and assessments (Well-to-Wheel), Hydrogen and methanol economy, alternative fuels on C1-basis, fisher-tropsch fuels, OME, bio-based oil fuels, biodiesel, green diesel, HEFA, bio-based alcohols, legislation of fuels.

**Intended Learning Outcomes:**
This module aims at making the students familiar with the industrial processes to produce renewable fuels. They are able to set up material and energy balances of these processes and assess their sustainability. Limitations with respect of raw material supply, energetic efficiencies and market requirements are understood. The students understand the interactions of fuel market and energy market.

**Teaching and Learning Methods:**
The module consists of a lectures and exercises. Contents of the lecture shall be imparted in speech and by presentation. To deepen their knowledge students are encouraged to study the literature and examine with regards to content the topics. In the exercises learned theory is applied with a practical orientation by means of arithmetic examples.

**Media:**
Hybrid live lectures & asynchronous mini-videos allowing distance learning, lecture Script and exercises via online platform, excursions to fuel production plants

**Reading List:**
• Jacob A. Moulijn, Michiel Makkee, Annelies E. van Diepen: Chemical Process Technology, Wiley (2013).
• George Olah et al.: Beyond Oil and Gas: The Methanol Economy, Wiley VCH (2006)
• Volker Schindler: Kraftstoffe für morgen: Eine Analyse von Zusammenhängen und Handlungsoptionen, Springer (1997)
• Martin Kaltschmitt, Hans Hartmann, Hermann Hofbauer: Energie aus Biomasse; Grundlagen, Techniken und Verfahren,SpringerVieweg (2016)
• Jochen Lehmann, Thomas Luschtinetz: Wasserstoff und Brennstoffzellen, Springer (2014)

**Responsible for Module:**
Burger, Jakob; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Production of renewable fuels (Tutorial, Straubing) (Übung, 2 SWS)
Burger J [L], Burger J, Groh D, Rosen N

Production of renewable fuels (Tutorial, Garching) (Übung, 2 SWS)
Burger J [L], Burger J, Groh D, Staudt J

Production of renewable fuels (Lecture, Straubing) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Staudt J

Production of renewable fuels (Lecture, Garching) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Staudt J
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0008: Enzyme Engineering | Enzyme Engineering [EE]

Version of module description: Gültig ab summerterm 2022

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
To proof whether the students are able to show ways to optimize enzymes in their properties and to perform this methodically, a written examination takes place with a duration of 60 minutes and a written seminar report must be created.The total grade consists of the written exam grade (67%) and the grade of the seminar report (33%).

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
This course aims to convey molecular biology and protein chemistry approaches to optimize enzymes especially by variation of the primary structure. Essential contents are: analysis of the limitation at the molecular level, rational methods, computer-based methods, evolutionary and combined procedures, high-throughput methods, robotics. The seminar aims to convey basic bioinformatical tools used in rational enzyme design such as ligand docking, energy minimization and rational introduction of mutations. These methods will be practiced on real enzymes and used to generate improved enzyme variants for a specific engineering target.

**Intended Learning Outcomes:**
After participating in the lecture the students will be able to indicate options for the improvement of technically limited enzymes, to estimate the necessary effort for these improvements and they own the theoretical ability to put these improvements into practice. After having participated in the seminar the students are able to use different bioinformatical tools for rational enzyme design and are able to evaluate the results of the generated informatical predictions.

**Teaching and Learning Methods:**
The lecture will be performed as ex-cathedra teaching to provide the students with all necessary fundamentals. In addition, the students review single methods and procedures by themselves e.g. based on current scientific literature and present this review to each other in a presentation. In the seminar, the students will be guided through the single steps of a rational enzyme engineering approach with the help of a script. The results of these steps will be summarized in a written report to put the single steps into a larger context.

**Media:**
PowerPoint, lecture script, scientific publications

**Reading List:**
Recommendations:
"Directed Enzyme Evolution: Screening and Selection Methods” (Methods in Molecular Biology) and “Directed Evolution Library Creation: Methods and Protocols” (Methods in Molecular Biology), both Frances H. Arnold, George Georgiou (publisher), Springer, Berlin
“Protein Engineering Protocols” (Methods in Molecular Biology), Katja M. Arndt and Kristian M. Muller (publisher), Springer, Berlin.

**Responsible for Module:**
Sieber, Volker; 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

## CS0009: Enzymatic Biotransformations | Enzymatic Biotransformations [IBT]

Version of module description: Gültig ab winterterm 2023/24

| Module Level: | Language: | Duration: | Frequency: |
|---|---|---|---|
| Master | English | 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 students should be able to understand and describe possibilities and limitations of established industrial enzymatic processes. This understanding and its application to derive ways to improve existing processes, making them more sustainable and to establish new ones, a written examination takes place with a duration of 90 minutes (approved tool: calculator). As a voluntary mid-term effort, the students can take part in three online test within the Moodle course of the exercise. If they achieve at least 65% of the points in these tests, a bonus of 0.3 will be credited on the grade of the written examination (however, an improvement of the grade from 4.3 to 4.0 is not possible).

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
The lecture provides a broad overview about applications of enzymes in industrial processes and detailed insight into the corresponding technically important aspects by means of current examples. Essential contents are: industrially relevant properties of enzymes, essential enzyme classes and the most important enzymatic mechanisms, whole cell catalysis vs. enzyme catalysis, biocatalysis vs. classical chemical catalysis, methods of enzyme immobilization, enzymes in aqueous and non-aqueous systems, enzymatic reactions combined with chemical reactions, large-scale supply of enzymes. On the application side, biotransformations which are necessary for the conversion of biogenic ressources are treated as well as reactions for the synthesis of bulk chemicals, fine chemicals and food additives.

**Intended Learning Outcomes:**
After participating in the lecture the students will be able to review possible applications of enzymes in different chemical and technical processes, to understand the behaviour and limitation of enzymes in these processes and to derive ways to establish new reactions biocatalytically and to propose technically meaningful scenarios for newly developed enzymatic processes respectively.

**Teaching and Learning Methods:**
The lecture will be performed as ex-cathedra teaching which is interrupted by queries to familiarize students with all necessary basics and to stimulate independent, critical thinking. In the exercise, the students will deepen the knowledge they have learned and solve specific problems of varying complexity, either alone or in group work.

**Media:**
PowerPoint, white board, exercise sheets or online questions

**Reading List:**

**Responsible for Module:**
Sieber, Volker; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Enzymatic Biotransformations (Exercise) (Übung, 1 SWS)
Sieber V [L], Arana Pena S, Hupfeld E

Enzymatic Biotransformations (Lecture) (Vorlesung, 2 SWS)
Sieber V [L], Sieber V
For further information in this module, please click campus.tum.de or here.

## Module Description

# CS0012: Artificial Intelligence for Biotechnology | Artificial Intelligence for Biotechnology [AI]

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The module examination takes the form of a presentation  followed by discussion. The learning outcomes are verified by a group project (3-4 students per group). The presentation of the developed code and the results of the project will be done together as a group, with each group member presenting one part. The presentation should be equally divided among the group members. After the presentation, each group member is asked individual questions about the project. The final grade will be based on the presentation and results of the project (duration of presentation and questions: approx. 30 min depending on group size; approx. 8-10  minutes per student).  As a voluntary mid-term effort, the students can take part in a multiple-choice test (duration: 10 minutes). If they achieve at least 65% of the points in this test, a bonus of 0.3 will be credited on the grade of the presantation (however, an improvement of the grade from 4.3 to 4.0 is not possible).

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Mathematical Skills in Linear Algebra and Statistics as well as Programming Skills in Python are expected

**Content:**
Technologies that generate analyses or predictions based on data can be found in almost all areas of our daily life (e.g. recommender systems, autonomous driving, and credit card fraud detection). These methods are also important for analyzing biological and biomedical data, e.g. for finding novel patterns in biological data, predicting the disease state of a patient, or the 3D structure of proteins. In this course, we will learn the fundamentals of machine learning and will apply these methods to various real-world problems.

The following contents will be treated exemplarily:
- Similarity and Distance Metrics
- Data Preprocessing and Visualization
- Dimensionality Reduction (e.g., Principal Component Analysis)
- Classification (Nearest-Neighbor, Logistic Regression, Decision Trees, Support Vector Machines (SVM))
- Model Selection and Hyperparameter Optimization (Confusion Matrix and Evaluation Measures, Cross-Validation, Hyperparameter tuning techniques, Common problems such as Over- vs. Underfitting)
- Clustering (K-Means, Hierarchical Clustering)
- Regression Models (Linear Regression, Support Vector Regression)

AI-based technologies have the potential to support many areas of biotechnology and sustainability, e.g. by guiding downstream research with data-driven predictions or supporting decision-making with demand forecasts. In this course, we will look at suitable practical examples and demonstrate their potential.

**Intended Learning Outcomes:**
The students know the fundamental and most important artificial intelligence, especially machine learning, methods and are able to apply them independently on various real-world problems. The students learn the basics of the programming language Python (one of the leading programming languages in the field of machine learning) and are able to implement and apply machine learning algorithms in Python. In addition, students are able to visualize and interpret different types of data and results independently. Students will understand how artificial intelligence can support areas of biotechnology and sustainability and are able to assess the potential of AI-based approaches in sustainability projects.

**Teaching and Learning Methods:**
Lectures to provide the students with all necessary fundamentals of artificial intelligence, especially of machine learning which they will need to independently apply these concepts to real-world data. In the exercises the students are introduced to the programming language Python, as well as to apply and implement these algorithms for specific case studies.

**Media:**
The lecture shall mainly be done by using PowerPoint presentations. During the exercise the students work at PCs to gain confidence in using the programming language Python. Students implement various machine learning methods in Python (e.g. using Jupyter Notebooks) and apply them on various examples. Students work on real world problems to implement learnt skills and to gain confidence in applying these different methods independently.

**Reading List:**
Murphy, K. P. (2012). Machine learning: a probabilistic perspective. MIT press.
Bishop, C. M. (2006). Pattern recognition and machine learning. Springer.
Raschka, S. (2017). Machine Learning mit Python. mitp Verlag.

Friedman, J., Hastie, T., & Tibshirani, R. (2001). The elements of statistical. Springer.

**Responsible for Module:**
Grimm, Dominik; 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

## CS0019: Chemistry of Enzymes | Chemistry of Enzymes [COE]

Version of module description: Gültig ab winterterm 2022/23

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

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

**Description of Examination Method:**
To proof whether the students are able to understand and to describe more complex enzymatic reaction mechanisms and deduce starting points for new enzymes from that, an oral examination takes place with a duration of 30 minutes.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
The lecture first gives an insight into the kinetic processes of enzymatic reactions and their descriptions. Then the katalytic mechanisms from a chemical point of view are presented and analyzed by means of enzymes of all six enzyme classes (e.g. acid/base catalysis in hydrolases, one-electron reactions, oxygenation, radical catalysis etc), whereby here more complex mechanisms are illuminated. The different coenzymes are introduced and their interaction with the substrates and the protein backbone is explained. For selected enzymes the mechanisms are presented in relation to the applications.

**Intended Learning Outcomes:**
After participating in the module sessions, students will be able to understand which complex catalytic mechanisms proceed in enzymes and how they are analyzed. This enables them to assess which chemical reactions are enzymatically possible and which non-natural modifications are necessary to establish new reactions. Thus, the students can for example open up the function of newly found enzymes and develop new enzymes

**Teaching and Learning Methods:**
The lecture will be performed as ex-cathedra teaching to familiarize the students with all necessary basics. The lecture is interrupted by short exercises/question-answer units to stimulate independent, critical thinking. In the seminar, the students will acquire the mechanisms for selected enzyme systems in self-research, introduce them to their fellow students and solve in a group work concrete problems of varying complexity.

**Media:**
PowerPoint, script, task sheets

**Reading List:**

**Responsible for Module:**
Dr.-Ing. Ammar Al-Shameri

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

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

# Module Description

## CS0026: Advanced Concepts of Bioinformatics | Advanced Concepts of Bioinformatics

Version of module description: Gültig ab winterterm 2023/24

| Module Level:<br>Master | Language:<br>English | Duration:<br>one semester | Frequency:<br>summer semester |
|---|---|---|---|
| Credits:*<br>5 | Total Hours:<br>150 | Self-study Hours:<br>90 | Contact Hours:<br>60 |

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

**Description of Examination Method:**
Learning outcomes shall be verified in a written test. Tasks shall be specified by means of which the students are to demonstrate that they know the bioinformatic methods imparted as part of the module and that they have understood and are able to apply them for specific case studies. Exam duration: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Module Biochemistry, WZ1631 Bioinformatics, CS0001 Foundations of Computer Science, Knowledge Linux Command Line Interface, Programming Skills in Python

**Content:**
In this course state-of-the-art methods in statistical genetics, genome-wide association studies, analysis of complex biological networks, protein-analysis as well as modern machine learning methods for genomic data are investigated and applied on various case-studies.

**Intended Learning Outcomes:**
The students know state-of-the-art bioinformatics methods and are able to apply them independently on various real-world problems. The students lern to implement custom Python scripts to analyse, visualise and interprete the results of these methods independently.

**Teaching and Learning Methods:**
Lectures to provide the students with the theoretical and practical concepts of state-of-the-art bioinformatics methods, which they will need to independently apply these methods on real-

world data. In the exercises the students will apply these tools on concrete case studies and will implement custom Python scripts to analyze, visualize and interpret the results.

**Media:**
The lecture shall mainly be done by using PowerPoint presentations. During the exercise the students work at PCs to gain confidence in using the bioinformatics tools. Students implement various custom Python scripts (e.g. using Jupyter Notebooks) to analyze, visualize and interpret the results of these tools. Students work on real world problems to implement learnt skills and to gain confidence in applying these different methods independently.

**Reading List:**
Pevsner, J. (2017). Bioinformatics and functional genomics. Wiley Blackwell.

**Responsible for Module:**
Dominik Grimm

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

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

# Module Description

## CS0032: Seminar on Optimization Methods and their Application | Seminar on Optimization Methods and their Application [SemOMA]

Version of module description: Gültig ab summerterm 2023

| Module Level:<br>Master | Language:<br>English | Duration:<br>one semester | Frequency:<br>summer semester |
|---|---|---|---|
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The examination consists of a written seminar paper as well as an oral presentation & discussion. The seminar paper should cover 15–20 pages and be written in the style of current publications of peer-reviewed journal articles. In addition to the seminar paper, optimization models and methods may have to be implemented in order to conduct numerical analyses, which will be handed in as a digital appendix. At the end of the module, students present their work in a 45 minutes presentation. Both parts (the written paper and the presentation) are weighted equally to the final grading.

**Repeat Examination:**

**(Recommended) Prerequisites:**
The module covers optimization models and methods and their application in operations research. To study these models and methods, methodological knowledge on optimization methods as obtained, e.g., in the module CS0098 (Operations Research) is required.

**Content:**
The seminar focuses on recent research developments on varying topics related to optimization methods and their application in operations research. Students learn to model practical problems arising in different areas of operations research as optimization problems and to solve the resulting problems using suitable methods. Thereby, mathematical optimization models and methods from areas such as (mixed-integer) linear programming and network optimization (e.g., shortest path or network flow problems) are used to solve relevant practical problems.

**Intended Learning Outcomes:**
The objective of the module is to equip the participants with the necessary skills for writing academic papers and tools for a successful master's thesis project.

Specifically, the aim is to be able to:
- Read and understand recent research contributions
- Pursue interesting and relevant research questions
- Conduct a literature study and/or numerical study and/or implementation concerning a specific topic
- Structure and organize research methods and results
- Write a seminar paper
- Present research findings and defend them in an academic discussion

**Teaching and Learning Methods:**
In an introductory session, the current theme of the module is explained by the lecturer and the various available seminar topics are elaborated in detail. Moreover, information on relevant literature for the problem settings is introduced, which forms the basis of the students' seminar papers. After the introductory session, students will work out their assigned topics independently own or in small groups by using their abilities of conducting literature research, mathematical modelling, programming, and quantitative analyses. Throughout the project, they receive guidance from a supervisor. Different milestones such as a preliminary outline of the seminar paper, first research results, and the final paper are to be achieved. Following the submission of the final paper, presentations and discussions of all students' seminar papers are conducted, where also presentation, moderation, and discussion skills are trained.

**Media:**
Research paper; presentation slides

**Reading List:**
F. Petropoulos et al. - Operational Research: Methods and Applications, Journal of the Operational Research Society, Volume 75, Issue 3, pp. 423-617 (2024)
M. Carter, C. C. Price, G. Rabadi - Operations Research: A Practical Introduction (2nd ed.), Chapman and Hall/CRC (2018)

**Responsible for Module:**
Thielen, Clemens; 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

## CS0086: Wood-based Resources | Wood-based Resources

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Exam achievement shall be done in the form of a test. Product pathways of forestry and forest industry shall be reflected here. Classification of economic and ecological aspects of forestry and forest industry from cultivation to material and energetic use shall be explained by using examples of particular cases. Recognition of wood and wood materials shall be shown. The relation of knowledge of forestry and forest industry with regard to knowledge of different woods and wood utilisation will be evaluated at a ratio of 1 to 1. The answers require own formulations from the respective technical jargon of forestry and forest industry.
Type of exam: In writing. Exam duration: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**

**Content:**
The module aims at providing in-depth knowledge to the students in the field of forestry and forest industry from harvest to the use of wood. Special emphasis is given to the interfaces concerning wood use (sawing, wood materials and paper industry) and energy wood production. In a further aspect differences of woods shall be addressed from a microscopic point of view through to their field of application in the manufacturing industry. Therefore, students learn to classify woods microscopically and macroscopically.

**Intended Learning Outcomes:**
After attending the module the student shall be able to characterise the product pathways in forestry from crop establishment through to material and energetic use of wood. He distinguishes different forms of economy and is able to classify them according to economic, social and

ecological aspects. He recognises differences of woods, knows various new products produced from wood and understands their production paths and their markets.

**Teaching and Learning Methods:**
The course attendance of forestry and wood consists of a lecture and exercises. For this purpose powerpoint presentations amd practical training material shall be used. A study trip to wood processing plants including lectures from qualified personnel providing information from experience on site with common rounds of questions provides in-depth knowledge of the production paths. A socalled wood block determination, i. e. the determination of wood by means of different genuine wood samples, will be performed by a magnifying glass 10x.

**Media:**
The following forms of media apply: Script, powerpoint, films, for determination exercises also branches and leaves of shrubs to be determined. Study trip to companies with guided tour of processing and treatment of wood. Determination of wood with a magnifying glass 10x.

**Reading List:**
D. Fengel and G. Wegener: Wood. Publisher: De Gruyter, https://doi.org/10.1515/9783110839654
Jörg van der Heide, 2011: Der Forstwirt. (The Forester) Publisher: Ulmer (Eugen); Auflage: 5th edition. (September
26, 2011)
Language: German
ISBN-10: 3800155702
ISBN-13: 978-3800155705; D. Fengel, G. Wegener: Wood Verlag Kessel, www.forstbuch.de

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Wood-based Resources (Exercise) (Übung, 2 SWS)
Zollfrank C [L], Röder H, Zollfrank C

Wood-based Resources (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Röder H, Zollfrank C
For further information in this module, please click campus.tum.de or here.

## Module Description

### CS0100: Microbial and Plant Biotechnology | Microbial and Plant Biotechnology [MPBioTech]

Version of module description: Gültig ab summerterm 2023

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

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

**Description of Examination Method:**
In order to check whether students have understood and are able to apply the principles and relevant methods and techniques of biotechnological production processes, the students answer questions about production processes and fermentation strategies, as well as on important methods and applications in plant biotechnology in a written exam (90 min) and prove that they have understood the correlations of metabolism. Allowed tools are calculators.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Fundamentals of Biology or of cell and microbiology from the Bachelor's courses

**Content:**
In the lecture microbial biotechnology relevant topics and techniques of microbial biotechnology are presented. This includes the quantitative description of the metabolic performance of microorganisms, industrially relevant substrate sources, metabolic engineering strategies as well as examples of industrial production processes (e.g.: alcohols, amino and organic acids).
In the lecture plant biotechnology the most important model and crop plants in biotechnology are presented, classified and their morphological and physiological properties are emphasized. Major questions, methods and solutions will be discussed with thier pros and cons. Some of the topics to be discussed: legal framework, major appilcation of current plant genetic engineering, the Arabidopsis model system, snovel concepts for yield and quality improvement. One focus is on the challenges for agriculture caused by climate change and sustainable solutions.

**Intended Learning Outcomes:**
Upon successful completion of the module, students will be familiar with the principles and techniques of relevant microbial bioprocesses. The students have acquired knowledge of fermentation processes and are able to develop strategies for process control for selected product classes. The students have learned to quantitatively describe microbial growth and fermentation processes. The students have acquired in-depth knowledge of relevant production processes for selected products of industrial biotechnology and understand their importance for the development of sustainable chemistry. Also, the students know the most important methods and applications in plant biotechnology and are able to assess them.

**Teaching and Learning Methods:**
The contents of the lectures are conveyed by a talk of the lecturer, based on PowerPoint presentations. The blackboard might additionally be used to explain more complex relationships. To a limited extent, this can be supplemented by self-study of the literature mentioned in the lecture.

**Media:**
PowerPoint, whiteboard

**Reading List:**
Microbiology – an evolving science, J. L. Slonczewski, J. W. Foster, W W Norton & Co Inc, 4th edition, ISBN: 978-0-393-61403-9 (available in the library)
Molecular Biology of the Gene, I. D. Watson, T. A. Baker, A. Gann, M. Levine,
Losick, Pearson, 7th edition, ISBN-13: 978-0321762436 (available in the library)
Biotechnology, R. D. Schmid, C. Schmidt-Dannert, Wiley-VCH, 1st edition,
ISBN: 978-3-527-33515-2 (available in the library, eBook)
Industrial Microbiology, D. B. Wilson, H. Sahm, K.-P. Stahmann, M. Koffas,
Wiley-VCH, 1st edition, ISBN: 978-3-527-34035-4 (available in the library)
Industrial Biotechnology – Products and Processes, C. Wittmann, J. Liao,
Wiley-VCH, volume 4, ISBN: 978-3-527-34181-8 (available in the library, eBook)
Industrial Biotechnology – Microorganisms, C. Wittmann, J. Liao,
Wiley-VCH, volume 4, ISBN: 978-3-527-34179-5 (available in the library, eBook)
Campbell Biology N. A. Campbell, L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky, J. B. Reece, Pearson, 11th edition (2018) (available in the library)

**Responsible for Module:**
Blombach, Bastian; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Microbial Biotechnology (Vorlesung, 2 SWS)
Blombach B [L], Blombach B

Applied Microbiology and Metabolic Engineering (Lecture) (Vorlesung, 2 SWS)
Blombach B [L], Blombach B, Glawischnig E

Plant Biotechnology (Lecture) (Vorlesung, 2 SWS)
Glawischnig E [L], Glawischnig E
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0101: Renewables Utilization | Renewables Utilization

Version of module description: Gültig ab winterterm 2020/21

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Assessment takes a written examination (90 minutes), with students to unterstand and to apply structure, transformation and use of different renewable resources. Students are required to answer questions using individual formulations and outline structures and reactions. In addition, sample calculations are to be worked out.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic lectures in chemistry; Basics on renewables utilization

**Content:**
Various types of ingredients of renewable raw materials: sugars, polysaccharides, fats and oils, amino acids, proteins, terpenes, aromatics. The following topics will be dealt with in more detail: structure, composition, occurrence, properties, analysis and type of added value or use in various examples.

**Intended Learning Outcomes:**
After completion of the modules, students understand the chemical composition of renewable resources as well as their production and application. Using this knowledge students are able to explain the respective advantages and disadvantages as well as analyze the underlying physical, chemical and biotechnological principles of their conversion into valuable products.

**Teaching and Learning Methods:**
Lecture and accompanying tutorial including individual work on specific examples.

**Media:**
Presentation, script, examples and solutions

**Reading List:**

**Responsible for Module:**
Rühmann, Broder; Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Renewables Utilization (Exercise) (Übung, 2 SWS)
Rühmann B

Renewables Utilization (Lecture) (Vorlesung, 2 SWS)
Sieber V [L], Rühmann B, Sieber V
For further information in this module, please click campus.tum.de or here.

## Module Description

### CS0102: Introduction to Game Theory | Introduction to Game Theory [IGT]

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
Learning outcomes are verified in a written exam (90 minutes). Students show the extent to which they have understood the taught game-theoretical definitions and terminology. They show to which extend they are able to use games in order to model problems from economics and engineering. They are also expected to apply important solution concepts to concrete games and answer comprehension questions concerning the properties and the advantages and disadvantages of the different solution concepts.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Module Mathematics (WZ1601) or Advanced Mathematics 1 (CS0175)

**Content:**
Cooperative and non-cooperative games, solution concepts for cooperative games, core, Shapley value, solution concepts for non-cooperative games, pure Nash equilibria, mixed Nash equilibria, dominant strategies, Bayesian games, modeling concrete case studies related to sustainability as cooperative and non-cooperative games

**Intended Learning Outcomes:**
Students have aquired basic theoretical and practical knowledge on cooperative and non-cooperative games. They know the basic definitions and terminology and are able to model sustainability-related problems from economics and engineering as games. Students know the most important solution concepts for cooperative games (such as the core and the Shapley value) and non-cooperative games (such as Nash equilibria and dominant strategies). They have gained a good understanding of these concepts and are able to analyze concrete games by using them.

**Teaching and Learning Methods:**
Lectures introduce basic knowledge; tutorials practice modelling of application problems as games and applying solution concepts to concrete examples.

**Media:**
Lectures given as presentations (projector and/oder blackboard), tutorials with group work and exercise sheets

**Reading List:**
Manfred J. Holler, Gerhard Illing, Stefan Napel - Einführung in die Spieltheorie, 8. Auflage, Springer Gabler, 2019.
Steven Tadelis - Game Theory: An Introduction, Princeton University Press, 2013.
M. J. Osborne and A. Rubinstein - A Course in Game Theory, MIT Press, 1994

**Responsible for Module:**
Thielen, Clemens; 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

## CS0104: Biogenic Polymers | Biogenic Polymers [Bioplar]

Version of module description: Gültig ab winterterm 2020/21

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
During the seminar, students independently work on a topic from the field of biogenic polymers, and give an oral presentation. Group work is optional. Assessment requires an oral examination (30 minutes). Students demonstrate their knowledge of physico-chemical properties of biogenic polymers as well as possible applications. Students are able to develop options for chemical synthesis and analysis of physico-chemical properties of bioplastics. No further tools are allowed in the examination.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Successful participation in "Basics in Chemistry" and knowledge of materials and chemical compounds, or comparable knowledge on chemistry and physics.

**Content:**
The module deals with structure and function of natural bio-macromolecules (in particular polysaccharids and proteins). Furthermore, basics of biogenic polymers will bei discussed in the view of polymers holding potential for applications in future technology. The topic of chemical synthesis and derivatization of bioplastics for use in industry is introduced (e.g. cellulose derivatives). Special focus is set on the development of options for chemical synthesis and its competent application. Physico-chemical properties of bioplastics as well as their characterization is central to the lecture.
The seminar takes the form of a journal club with students independently work on reserach papers and their presentation to fellow students.

**Intended Learning Outcomes:**
After participation, students are able to classify different kinds of bioplastics with respect to their possible application. They are competent to evaluate the production processes of biopolymers used in technology and can classify them according to their profile of properties. The module enables students to decide on appropriate synthesis methods to meet specific requirements in the industry. Students will also be able to use physico-chemical analysis methods in a competent way.

**Teaching and Learning Methods:**
Lecture (talks given by teaching staff using PowerPoint media, books and additional written document), seminar (independent work on a topic including a presentation, peer instruction and constructive criticism)

**Media:**
Presentations, slide notes

**Reading List:**
Endres, H.J., Seibert-Raths, A., Technische Biopolymere, Carl Hanser Verlag, München, 2009

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Biogenic Polymers (Seminar) (Seminar, 1 SWS)
Zollfrank C [L], Helberg J

Biogenic Polymers (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Zollfrank C
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0105: Modelling and Optimization of Energy Systems | Modelling and Optimization of Energy Systems [MOES]

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Assessment is done in a written examination (90 minutes). Participants of the course solve programming tasks to demonstrate that they are able to apply the methods aquired in the course. By answering questions related to case examples they show that they have learned to put things into their proper context.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Bachelor modules Mathematics, Physics, Numerical Methods;
Basic knowledge in Energy technology; basic programming experience (ideally with Matlab)

**Content:**
Basics of Modelling and Simulation:
- physical models
- data-based models (look-up tables, polynomials, neural networks)
- methods for generating models
Fundamental optimization methods:
- linear optimization (linear regression)
- nonlinear optimization

**Intended Learning Outcomes:**
After attending the course the participants understand basic methods for creating models, simulation and optimization. In addition, they are able to apply these methods by creating appropriate program code in Matlab. Furthermore, the participants acquire Matlab programming experience.

**Teaching and Learning Methods:**
The module consists of a lecture and an excercise. Lectures include presentations whose content is deepened by solving excercise problems autonomously. In order to improve the learning outcome, participants work at homework excercise problems. These are discussed in the next lecture.

**Media:**
PP presentation, whiteboard, demonstration of programs

**Reading List:**
S. R. Otto & J.P. Denier, An Introduction to Programming and Numerical Methods in MATLAB, Springer, London, 2005
O. Nelles, Nonlinear System Identification, Springer, Berlin, 2010

**Responsible for Module:**
Kainz, Josef; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Modelling and Optimization of Energy Systems (Vorlesung mit integrierten Übungen, 4 SWS)
Kainz J [L], Kainz J
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0134: Conceptual Process Design | Conceptual Process Design

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
The exam performance is effected by an oral exam. It is reviewed whether the students know the fundamentals of conceptual design of chemical and biotechnological processes and if they can apply this knowledge on the design and evaluation of complex processes. The exam consists of two parts: (a) 30 minutes preparation through solving a given problem set (b) 30 minutes of oral examination. In the beginning of part (b) the results of part (a) are presented by the student. (total duration 60 min)

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Knowleadge of thermodynamics and apparatusses used for fluid sparations processes. It is recommended to visit at least the course "Introduction of Process Engineering" first.

**Content:**
Basics of cenceptual design of processes; Basics of computational process design including calculation of process parameters; transfer of fundamental scale-up criteria towards real problem solving; Balancing of all process streams; Deepened knowledge of engineering principles.

**Intended Learning Outcomes:**
The students are qualified to understand the fundamentals of design, calculations, and balancing of chemical processes and fluid separation courses after the course. They will aquire knowledge of different challenges of process design and how to master them.

**Teaching and Learning Methods:**
The module consists of lectures and parallel tutorials. Contents of the lecture shall be imparted in speech and by presentation. In the exercises performed as part of the module learned theory

shall directly be applied with a practical orientation by means of calculations and examples from targeted aspects of process design and calculation. based on a direct comparison of a chemical process with it´s biotechnical alternative they learn to apply their knowledge on reality based challenges. Additionally they will be qualified by an in-depth knowledge of the design of operation units including calculation of process parameters based on utilization of selected software tools.

**Media:**
Panel, slides, scripts, practical exercises

**Reading List:**
Moulijn et al. (2013). Chemical Process Technology. – John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, United Kingdom.
# Biegler et al. (1997). Systematic Methods of Chemical Process Design. – Prentice Hall.
# Doherty, M.F., Malone, M.F. (2001). Conceptual design of distillation systems. – Boston: McGraw-Hill.
# Gmehling, J., Kolbe, B., Kleiber, M., Rarey, J. (2012). Chemical Thermodynamics for Process Simulation. 1. Auflage. Weinheim: Wiley – VCH
# Grassmann, P., Widmer, F., Sinn, H. (1997). Einführung in die Thermische Verfahrenstechnik. 3. vollst. überarb. Auflage. Berlin: de Gruyter.
# Stichlmair, J.G., Fair, J.R. (1998). Distillation: Principles and Practice. – New York: Wiley – VCH.

**Responsible for Module:**
Burger, Jakob; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Conceptual Process Design (Lecture) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Ibanez M, Staudt J

Conceptual Process Design (Exercise) (Übung, 2 SWS)
Burger J, Rosen N, Wolf A
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0147: Energy Efficient Buildings | Energy Efficient Buildings [EEB]

Version of module description: Gültig ab winterterm 2022/23

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Students demonstrate their knowledge and understanding of the differenct aspects of energy efficient buildings in form of a written examination (90 minutes). Students deliver definitions, describe and outline relevant processes, mechanisms and requirements of energy efficient buildings. Furthermore, students calculate different technical specifications and parameters based on provided practice-oriented examples.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basics of physics, Basics of energy technology

**Content:**
The course focuses on the variety of options for implementation and/or enhancement of energy efficiency in new and existing buildings. This includes an introduction to relevant expert knowledge of energy and ressource efficient building materials and construction. In addition, typical measures for the enhancement of energy efficiency in existing buildings will be presented and evaluated concerning ther sustainability. The second part of the module is concerned with renerwable energy based systems for heat and warm water provision of buildings. Specific advantages and disadvantages of the presented technologies will be discussed in regards to building and usage type. In addition to the presentation of individual measures, it will be analyzed how concepts for energy efficient buildings can be include in modern building infrastructure and on living quarter scale.

**Intended Learning Outcomes:**
"After successful completion of the module, students acquire in-depth understanding of  factors determining the energy efficiency of buildings and relevant legal requirements. Students can

evaluate the  sustainability of actions to enhance the energy efficiency of (existing) buildings. In addition, students can  understand as well as evaluate and explain advantages and disadvantages of systems for heat and warm water provision based on renewable energies in regards to building and usage type.

Students prepare short, practice-oriented tasks as homework in a project team (group work). Thereby, they acquire the ability to view and assess information within a limited period of time and solve practice-oriented questions. The edited information and results are passed on to the other participants accordingly with the focus on sharing results in the form of a written report as well as team work.

**Teaching and Learning Methods:**
The content is taught in lecturs and presentations. In addition, case studies and exercises will bei discussed. Students should bei encouraged to individual literature study and discussions on the theme.

**Media:**
PowerPoint, blackboard, videos

**Reading List:**
Bauer, M., Mösle, P., Schwarz, M. (201.): Green Building: Leitfaden für nachhaltiges Bauen. Springer Vieweg. Daten von Fachagenturen: BINE Informationsdienst, vom Bundesumweltministerium bzw. entsprechenden Landesministerien und anderen internationalen Organisationen.

**Responsible for Module:**
Vienken, Thomas; 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

## CS0149: Renewable Resources in Medicine | Renewable Resources in Medicine

Version of module description: Gültig ab summerterm 2023

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The Assessment consists of a written examination (90 minutes)

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Requirements for the successful participation is basic knowledge in chemistry, cell and microbiology, biochemistry, materials science and renewable ressources

**Content:**
The course provides basic knowledge on the human anatomy, cell biology on general and the cell membranes in particular. The interaction of materials with cell surfaces and tissue will be introduced. The general issues related to pharmacology and the fabrication of drugs from from renewable ressources will be discussed. The application of renwable resources as the main course topic in surgery, internal medicine, plastic and reconstructive surgery as well as wound dressings will introduced. Future tasks for the medical application of renewable resources are outlined. The legislative framework for application of medical products and fabrication will be discussed.

**Intended Learning Outcomes:**
The successful visit of this course enables the students to select materials from renewable ressources for relevant fields in medicine (skin, muscle, bone) and can particularly assess the valueof their applicability. They are able to apply the most important legislation in medical application and to validate the material reqeuiements for the application in humans (biocompatibility). They are able to identify and develop new concepts for sustainable materials

from renwable ressources in medicine due to their aquired medical, chemical and materials science knowledge and they can set the base for the potiental application of such materials.

**Teaching and Learning Methods:**
Lecture (talk by teaching staff) with media, seminar on case studies

**Media:**
Presentation, script, examples, case studies

**Reading List:**
The following literature is recommended: Buddy Ratner et al.: Biomaterials Science - An Introduction to Materials in Medicine, Elsevier

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

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

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

# Module Description

## CS0156: Material Application for Renewable Resources | Material Application for Renewable Resources

Version of module description: Gültig ab summerterm 2024

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
During the seminar, students independently work on a selected topic from the field of biobased materials and give an oral presentation with PowerPoint-handout (min. 10 slides). Group work is compulsory (3 – 5 persons). The students will implement their own online survey and present the findings in the context of the relevant literature in the presentation (each student has to present 5 minutes). The oral presentation shall be assessed according to content of the PowerPoint-handout and rhetoric aspects. The PowerPoint-handout summarizes the relevant literature, data, and key findings. Weighting: PowerPoint-handout 1, oral presentation 1.
The seminar work is not part of the written exam. However, midterm bonus points can be achieved which will have an effect on the individual final grade (-0,3).

Assessment requires a written examination (90 minutes). Students demonstrate their knowledge of physico-chemical properties and possible applications of biobased materials, as well as their environmental impact. Students are able to develop options for chemical synthesis and production processes of biobased plastics. No further tools are allowed in the examination.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Successful participation in "Basics in chemistry " and “Biogenic Polymers”, as well as knowledge of materials and chemical compounds, or comparable knowledge of chemistry and physics.

**Content:**
Lectures give an overview the applications for biogenic resources in materials industry. Starting with the chemical composition and physic-chemical properties of the raw materials, the module introduces students to production and processing of biodegradable and non-biodegradable

bioplastics, as well as of natural fibre composites. It also covers material properties, relevant fields of application, their environmental impact, as well as current market trends.
In the seminar, students independently work on research papers and based on that, give a presentation to fellow students.

**Intended Learning Outcomes:**
After successful participation, students are able to assess opportunities and barriers for the application of biobased plastics, as well as their environmental impact compared to conventional plastics. Above all, they are competent to select suitable feedstocks, classes and types of materials, as well as processes to meet the technical requirements of a specific target product, having lower environmental impact at the same time.

**Teaching and Learning Methods:**
Lecture (talks using PowerPoint slide media, books and additional written material), seminar (independent work on a selected topic with subsequent presentation, peer instruction and constructive feedback).

**Media:**
Presentations, slide notes

**Reading List:**
Endres, H.J., Seibert-Raths, A., Technische Biopolymere, Carl Hanser Verlag, München, 2009
Pickering, K. L. (Hrsg.): Properties and performance of natural-fibre composites, CRC Press, Boca Raton 2008
Lewin, M.(Hrsg.): Handbook of Fibre Chemistry, Marcel Dekker, New York, 1998

**Responsible for Module:**
Fink, Bettina; 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

# CS0164: Basics of Numerical Methods and Simulation | Basics of Numerical Methods and Simulation [NumS]

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Examination shall be done in the form of a written test. As an aid the materials (lecture slides, example programs) used during the lecture may be employed. The students show by solving programming tasks that they know the basics of Matlab and are able to employ it to implement simple numerical methods. They apply these methods to specific technical problems in case studies. In doing so, they also demonstrate their capability to discern which way to solve a problem is appropriate.
Exam duration: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
WZ1600 Physics, CS0 Mathematics

**Content:**
- Basics of programming using Matlab/Simulink
- simple numerical methods: Systems of linear equations, numerical integration & differentiation, finding zeros,
- numerical solution of differential equations
- application of methods by using case studies (e.g. mechanical and electric systems)
- basics of optimization

**Intended Learning Outcomes:**
After having participated in the module units the students understand basic concepts of various numerical methods. They can apply these methods to case studies presented in the course methods using self-created programs in Matlab/Simulink. In doing so, they have also learned

to implement different solutions and discern how appropriate to the problem they are. In simple cases, they are also able to evaluate their results in terms of plausibility and accuracy.

**Teaching and Learning Methods:**
The module consists of one lecture and an associated session of exercises. Contents of the lecture shall be imparted in a speech and deepened through independent preparation of exercises by the students. Processing of exercises is often done by independent preparation of programming tasks.

**Media:**
Presentations,  writing on the board, demonstration of programmes/scripts

**Reading List:**

**Responsible for Module:**
Kainz, Josef; 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

## CS0170: Advanced Modelling and Optimization | Advanced Modelling and Optimization

Version of module description: Gültig ab winterterm 2021/22

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>German/English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The examination is based on two project works (each 50% of evaluation).

The project works examine the understanding of the modeling and programming techniques discussed in the course. The project works includes, appling algorithms to solve problems, creating mathematical models for examplary problems, and discuss presented results. By this the students have to demonstrate that they have understood and can apply the mathematical models and methods to solve planning problems. The project paper serves the assessment of the understanding of the modeling and programming language.

For the project paper the participants get a randomly assigned fictive, extensive decision problem. For this problem, the following has to be prepared:
- a modeling of the problem as a mathematical program, as well as explanation of the program
- an implementation of the program in a known optimization and programming language
- a verbal and graphical explanation of the of the results for the original problem

The grading of the project paper is done by the following criteria:
- Correctness of modeling and implementation as well as of the results (60% of examination)
- Clarity, comprehensibility and efficiency of the implementation (30% of evaluation)
- correct language, typesetting and outer form of the paper (10% of evaluation)

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Operations Research (CS0098)

**Content:**
This course is about modeling, solving and analyzing planning and decision problems using mathematial concepts. The course teaches the basics of linear, discrete and dynamic optimization. In addition, there is an introduction to optimization and corresponding programming languages, as well as teaching methods for analyzing and structuring algorithms, designing suitable object-oriented data structures, applying known standard algorithms and connecting them to other resources and programming environments.

**Intended Learning Outcomes:**
After successful completion of the module students are capable of modelling planning problems. Students learn to model real life business problems by applying mathematical programming techniques. They can independently implement mathematical models by using an optimization language and heuristical approaches. They are able to solve the models within the scope of a case study and can interpret the results. Furthermore, they deepen their knowledge in several different modeling techniques and basics of object oriented programming.

**Teaching and Learning Methods:**
The module consists of a lecture and exercise courses, which are provided weekly. In the lecture the content is jointly developed with the students mainly by using slides. The exercise course repeats parts of the lecture contents by using examples and offering the opportunitis to implement poblems individually. The excercises give the student the opportunity to pose questions and receive immediately help from the teaching assistant.

**Media:**
Script, Presentation slides

**Reading List:**
Hilier, F. and Lieberman, G., Introduction to Operations Research, McGraw-Hill, 2009
Popp, Andreas: Modellierung und Optimierung mit OPL. epubli, 2015
Schildt, H.: Java, A Beginner's Guide, 5th Edition, McGraw-hill, 2011
Winston, W.: Operations Research - Applications and Algorithms. 4th ed. (internat. student ed.), Belmont, Calif. (Duxbury), 2004.

**Responsible for Module:**
Alexander Hübner alexander.huebner@tum.de

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

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

## Module Description

### CS0255: Current Topics in Machine Learning and Bioinformatics | Current Topics in Machine Learning and Bioinformatics [CTMLBI]

Version of module description: Gültig ab summerterm 2023

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

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

**Description of Examination Method:**
The learning outcomes are tested by a graded seminar presentation with a duration of approximately 45 minutes including a discussion with the audience. The seminar allows the students to assess the extent to which they can summarize a complex scientific work in the field of Machine Learning or Bioinformatics correctly and present it to an audience in a comprehensible and convincing way. Furthermore, to assess the skill to quickly understand, review and critically discuss recent research in these fields, the active participation and discussions of the other seminar presentations will be considered as well.

**Repeat Examination:**

**(Recommended) Prerequisites:**
Knowledge in Machine Learning and Bioinformatics (e.g. Bioinformatics (WZ1631) and Artificial Intelligence for Biotechnology (CS0012)) is expected

**Content:**
At the beginning of this course, introductory lectures about current topics in Machine Learning and Bioinformatics will be given. The following topics are treated exemplarily:
- Ensemble learners
- Neural Networks (Basic concept, Feedforward neural networks, Recurrent Neural Networks, Convolutional Neural Networks, Generative Models)
- Green Artificial Intelligence
- Genome-wide Association Studies
- Phenotype Prediction
- Protein-Protein Interaction Network Analysis
- Protein Prediction

- Data Driven Biotechnology
In this course, we will also talk about recent Machine Learning and Bioinformatics research and how it can support sustainability, e.g., by guiding downstream research with data-driven approaches. Furthermore, we will also look at Green Artificial Intelligence, a research direction that aims to make resource-intense AI development more sustainable. After introductory lectures, each student will analyze a recent scientific paper in these research areas in self-study and present it to the course. Active participation and discussions in all the other presentations is expected.

**Intended Learning Outcomes:**
After successful participation in this module, students will be able to understand and present recent research in Machine Learning or Bioinformatics. They are enabled to analyze recent scientific publications in one of the two fields. Based on this knowledge, they can summarize and present a scientific paper in a concise and understandable way as well as to discuss recent research in Machine Learning or Bioinformatics. Furthermore, students know about current research directions in these scientific fields and know how current Machine Learning and Bioinformatics research supports sustainability.

**Teaching and Learning Methods:**
At the beginning of this course, introductory lectures to current Machine Learning and Bioinformatics topics will provide additional and necessary fundamentals to understand recent scientific publications. Furthermore, each student will analyze a recent research paper in one of the two fields in self-study and present it to the course to train the ability to understand advanced concepts. Beyond that, for further training of these skills, the paper presentations will be discussed in the course.

**Media:**
Slide presentation, blackboard, discussion forums in e-learning platforms

**Reading List:**
Pattern Recognition and Machine Learning, Christopher M. Bishop
Deep Learning, Ian Goodfellow, Yoshua Bengio, Aaron Courville

**Responsible for Module:**
Prof. Dr. Dominik Grimm, Florian Haselbeck

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

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

# Module Description

## CS0260: Energy and Economics | Energy and Economics [EUW]

Version of module description: Gültig ab summerterm 2022

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

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

**Description of Examination Method:**
The examination will take the form of a written test (60 minutes). The students prove that they can understand and answer questions and the connections between the energy conversion, the conversion of renewable raw materials, the energy supply in general and the current energy-political and economic situation. Group work can be included and be part of the exam.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Prior participation and passing of the fundamentals of Thermodynamics module is required for participation in the Energy and Economics module.

**Content:**
The module deals with the basics of energy sources, climate change and the technology of the heat, electricity and fuel market and the use of renewable raw materials, including an introduction to simple technical systems and current topics on the energy industry. It also deals with electricity trading, CO2 trading and the current situation of various energy technologies.
In exercises small examples are calculated to the economy (production costs of heat and power of plants (e.g. combined heat and power plants).

**Intended Learning Outcomes:**
By participating in the module, students will be able to understand the energy sources and simple principles of energy conversion into heat and electricity. They can perform simple economic assessments of energy systems and understand related market mechanisms of the electricity and heat market.

**Teaching and Learning Methods:**
The module consists of a lecture with exercises. The contents of the lecture are conveyed in the lecture and through presentations.

**Media:**
Presentations, exercise

**Reading List:**
Kaltschmitt, M.; Hartmann, H.; Hofbauer, H.: Energie aus Biomasse, 2. Auflage, Springer, ISBN 978-3-540-85094-6, 2009
Karl, J.: Dezentrale Energiesysteme, Oldenbourg, ISBN 3-486-27505-4, 2004/

**Responsible for Module:**
Gaderer, Matthias; 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

## CS0261: Phytopharmaceuticals and Natural Products | Phytopharmaceuticals and Natural Products [Phytopharm]

Version of module description: Gültig ab summerterm 2022

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
Knowledge of the covered topics of phytopharmaceuticals and natural products compounds is assessed in a written examination (90 minutes). In addition, students are required to explain the medicinal effects of medicinal plants in the examination using examples.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Organic and anorganic chemistry, botany

**Content:**
Content of the lecture:
-definition of medicinal plants and phytopharmaceuticals
-position of phytopharmaceuticals in pharmacology
-compounding (tea drugs, soluble extracts, sCO2 extracts, steam destillation, pure substances)
-effect-determining components and frequent mechanisms (inflammation cascade, infections, coagulation system, neurotransmission, digestive system)
-typical medicinal plants grown in Europe
-international trade in medicinal plants
-important classes of compounds (terpenes, steroids, coumarine, alcaloids, vitamins, saccharides)
-quality determination and typical methods (chromatography)
-falsification and chemotype (chemical race)
-drug regulator affairs (authorisation, documents)
-use of medicinal plants in practice

**Intended Learning Outcomes:**
After their participation, students can explain the production of phytopharmaceuticals derived from typical medicinal plants (from collection to quality control). They can relate chemical compounds and medical effects of typical examples.

**Teaching and Learning Methods:**
The lecture takes the form of oral presentation given by teaching staff with the help of PowerPoint media, books and other written material.

**Media:**
PowerPoint presentation and printed handout. Laboratory equipment for experiments.

**Reading List:**
Deutschmann, F., Hohmann, B., Sprecher, E., Stahl, E., Pharmazeutische Biologie, 3 Bde., G. Fischer Verlag, 1992

**Responsible for Module:**
Riepl, Herbert; 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

## CS0263: Geothermal Energy Systems | Geothermal Energy Systems [GeoE]

*Potentials of geothermal energy supply*

Version of module description: Gültig ab winterterm 2022/23

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Students demonstrate their knowledge and understanding of geothermal systems and their potential for energy supply in form of a written examination (90 minutes). Students deliver definitions, describe and outline relevant processes for the geothermal energy supply. Furthermore, students calculate different technical specifications and parameters based on provided practice-oriented examples.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Successful completion of the module "Basics in engineering" and "Introduction to Energy conversion and Energy economy". Knowledge and interest in Geology and Physics are valuable.

**Content:**
The course focuses on the variety of options for geothermal energy supply. This includes an introduction to relevant geological expert knowledge such as formation of the earth, earth's structure, geothermal heat sources, the rock-cycle as well as mechanism of subsurface heat transport. After an introduction to deep geothermal exploration (drilling, drilling technology and related risks) the focus of the course is placed on shallow geothermal energy and use of ground-coupled heat pump systems.

This includes the design and working principle of a heat pump system and its integration in technical building equipment as well as the analysis of their ecological and economic sustainable operation on living quarter scale. The analysis is also done with regards to existing technical guidelines as well as legal boundary conditions. Practice-oriented tasks will be used to

demonstrate and critically evaluate the basic planning steps of heat pump systems and obtaining the relevant parameters. Existing and innovative geothermal exploration concepts will be analyzed and discussed against this background.

**Intended Learning Outcomes:**
After successful completion of the module, students acquire in-depth understanding of geothermal energy systems including relevant geological and hydrogeological processes. Students can evaluate the ecological as well as economic sustainability of geothermal heat source systems. They can test plausibility of dimensioning ground-coupled heat pump systems and understand, explain and comprehend heat transport processes and regeneration processes within the subsurface.

Students prepare short, practice-oriented tasks as homework in a project team (group work). Thereby, they acquire the ability to view and assess information within a limited period of time and solve practice-oriented questions. The edited information and results are passed on to the other participants accordingly with the focus on sharing results in the form of a written report as well as team work.

**Teaching and Learning Methods:**
The content is taught in lectures and presentations and strengthened by case studies and exercises. If applicable, the module is complemented by an excursion.

**Media:**
Lecture, Power Point presentation, blackboard, case examples, topics prepared and presented by participants.

**Reading List:**
Bayerisches Staatsministerium für Landesentwicklung und Umweltfragen (2005): Oberflächennahe Geothermie.
Bauer, M., Freeden, W., Jacobi, H., Neu, Th. (Hrsg.) (2018): Handbuch Oberflächennahe Geothermie. Springer Spektrum, 1. Auflage.
Stober, I. & Bucher, K. (2014): Geothermal Energy. Springer Spektrum, 1st edition.
Hölting, B., Coldewey, W.G. (2013): Hydrogeologie. Springer Spektrum, 8. überarbeitete Auflage.
Dassargues, A. (2018): Hydrogeology: Groundwater Science and Engineering, CRC Press, 1st edition.
Grotzinger, T. & Jordan, T. (2017): Press/Siever Allgemeine Geologie. Springer Spektrum, 7. Auflage
Grotzinger, T. & Jordan, T. (2014): Understanding Earth. W.H. Freeman & Company, 7th edition

**Responsible for Module:**
Vienken, Thomas; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Geothermal Energy Systems (Vorlesung mit integrierten Übungen, 4 SWS)

Vienken T [L], Vienken T
For further information in this module, please click campus.tum.de or here.

## Module Description

### **CS0264: Polymer Processing | Polymer Processing** [PolyProc]

*Processing of polymers intro plastic parts*

Version of module description: Gültig ab summerterm 2024

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
The content and learning objectives of the lecture are examined at the end of the semester in a written test (90 min). An oral pre-test containing safety relevant laboratory work issues must be carried out before the individual pratical course. A written report on the practical course consisting of approximately five pages must be submitted. The written report is an ungraded student achievement.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Polymer chemistry, polymer physics, rheology fluid mechanics, Biogenic Polymers

**Content:**
The lecture deals with unit operations, basic techniques and processes of plastic material processing, e.g. compounding, extrusion, injection molding, plastic part forming processes and also typical applications. In addition, methods for characterizing thermal and mechanical properties are presented. One focus here is the connection between the processing parameters and the end-use properties. The acquired knowledge is deepened in the accompanying practical course. Injection molding and extrusion tests are carried out and the test specimens are then characterized with regard to their thermal, optical and mechanical properties. Additional foci will be laid on the chemistry, structure and classification of polymers and plastic parts. The lecture also deals with the physical properties of polymers and plastic materials involving materials science. Characterization of the mechanical and thermal properties and their effects on processing, viscosity, viscoelastic behavio will be discussed

**Intended Learning Outcomes:**
In addition to the chemical-physical basics of polymeric materials, this module imparts the methodical knowledge about classic and modern innovative processing methods of polymeric materials. The students are able to sensibly classify plastic materials, their manufacture and use them for specific applications. The basics for the production technology of plastic materials are acquired. After successfully completing the module, students are able to select and use methods for processing plastic. They will be able to assess sustainability aspects of the polymer production process in terms energy consumption and materials use. Through practical work, the competence for the meaningful use of testing and characterization methods of polymer materials is acquired.

**Teaching and Learning Methods:**
Lecture (lecture by teaching staff with Power Point slide media, books and other written material), laboratory practical course (experimentation of the students under supervision)

**Media:**
Power Point slide presentations; Drawing and writing on a black board; Laboratory equipment for experimentation

**Reading List:**
Polymer Engineering; Technologien und Praxis; Peter Eyerer, Peter Elsner, Thomas Hirth
Polymer Extrusion; Chris Rauwendaal
Extrusion: The Definitive Processing Guide and Handbook; Harold F. Giles, Jr.
Einführung in die Kunsstoffverarbeitung; Michaeli, W.
Werkstoffkunde der Kunststoffe; Menges, G.

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Polymer Processing (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Helberg J

Polymer Processing (Practical) (Praktikum, 1 SWS)
Zollfrank C [L], Helberg J
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0266: Sustainable Chemistry | Sustainable Chemistry

Version of module description: Gültig ab summerterm 2024

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
The examination will take the form of a written test (60 minutes). In this examination the competence for the evaluation of chemical processes and for the derivation of optimization strategies shall be proven. No aids are permitted in the written examination. In order to additionally check whether the students are able to communicate scientific topics in front of an audience and whether they are able to critically deal with problems in individual steps, the results of the processing of the case studies are presented in the form of a 20-minute presentation alone or in a group. This presentation is ungraded study achievement.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Successful participation in the module "Basics in chemistry" or comparable knowledge in chemistry.

**Content:**
The module teaches basic principles of sustainable chemistry. Focus is set on the evaluation of chemical processes in view of efficiency, atom economy and amount of waste. In addition, optimizsation strategies related to catalytical methods, raw material and energy efficiency are discussed. Students individually prepare current topics related to sustainable chemistry and present them in the seminar.

**Intended Learning Outcomes:**
By attending the module events, students are able to highlight the principles of sustainable chemistry. Students can analyze the efficiency and waste quantities of chemical reactions and evaluate various alternative processes. Furthermore, they are able to discuss further chemical aspects of the conversion of renewable raw materials into valuable products. Through the

independent development of case studies, the students master all the steps that are important in the critical examination of problems (consideration of the example, development of criteria for evaluation, assessment, presentation of the results to an audience).

**Teaching and Learning Methods:**
Lecture with board addresses and presentations: Basic development and derivation of technical contents; seminar with written tasks. Consolidation of the technical learning contents through learning activity of the students themselves, e.g. through independent development of case studies from the field of sustainable chemistry.

**Media:**
Presentation, script, examples

**Reading List:**
Stanley E. Manahan: Green Chemistry, ISBN: 0-9749522-4-9

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Sustainable Chemistry (Seminar) (Seminar, 1 SWS)
Zollfrank C [L], Helberg J, Zollfrank C
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0267: Biological Materials | Biological Materials

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Understanding of the course contents and their application will be tested in a written exam of 90 minutes duration. In detail, the students are required to describe the physical and chemical foundations of the formation, as well as relations between the hierarchical structure and properties, of typical biological materials. Further, the transfer of this knowledge to technological applications and to the design of novel biologically inspired materials, as covered in the course, is a test subject. Lecture notes are not permitted.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge in geometry and chemistry

**Content:**
The module Biological Materials in Nature and Technology covers important biological functional materials, based on basic materials scientific knowledge. This encompasses such materials that fulfill, in their biological system, or in a technological application, either in native state, or modified, one or more specific functions. Differences and similarities to classical engineering materials are pointed out. In addition to the modules Bioinspired Materials and Instrumental Analysis, the students learn important methods for structural and property analysis. After a presentation of the classification of biological materials, students- are taught the basic correlations between hierarchical structuring and macroscopic properties. As the most important complex, the influence of hierarchical structuring on the mechanical properties of materials will be discussed. The students learn, which modes of failure can occur in biological systems and how they are influenced. In this context, modification routes for biological materials are shown and discussed.

**Intended Learning Outcomes:**
After successful completion of the module, the students are enabled to name criteria for a proper usage of biological materials. They can name specialized methods for the analysis of hierarchical structures and the derived material properties and explain the correlations between structure and external properties. Further, they are able to describe tailored modification routes for biological materials.

**Teaching and Learning Methods:**
Lecture with discussion and case studies

**Media:**
Presentation, slides

**Reading List:**
Structural Biological Materials: Design and Structure-Property Relationships. Eds Elices M, Pergamon-Elsevier Science Ltd, Oxford, (2000).
Fratzl P & Harrington MJ. Introduction to Biological Materials Science. Wiley VCH, Weinheim, Germany, (2015).

**Responsible for Module:**
Van Opdenbosch, Daniel; 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.

## Electives TUM (max. 18 ECTS) | Electives TUM (max. 18 ECTS)

## Module Description

## WZ4202: Political and Social Perspectives of Renewable Resources | Political and Social Perspectives of Renewable Resources

Version of module description: Gültig ab winterterm 2015/16

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
Oral presentation of the group project work, review paper for a scientific journal. The learning outcomes are assessed by a group project work concerning a selected topic related to the political and social perspectives of renewable resources. Therefore students have to prepare a scientific paper for an international journal of their choice and give a short oral presentation about the work done for the paper, similar to what would be expected in a 15 minute conference presentation.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Knowledge of sustainable resources (materials and energy). Scientific writing.

**Content:**
In the lectures a number of examples of societal aspects of Sustainable Resource programs will be presented and discussed. Backgrounds are global developments such as urbanization, the rise of countries like China and India, resource availability and technological developments. Case studies deal with tropical forestry and pros and cons of tropical hardwood uses, urban planning, vernacular architecture and the use of renewable resources We take a tour around the world and look at social housing programs in Europe, Brazil and South-East Asia. Furthermore we look at successes and failures in the German/European energy policies in comparison to the United States.

**Intended Learning Outcomes:**
After this course, students should be able to:

1. Develop SR stimulation programs on country or regional level and priority analysis of renewable resource applications
2. Assess priorities for development and application of renewable resources in countries with different levels of development
3. Critically analyze existing SR programs taking into account social values of stakeholders,
4. Assess impacts of global developments such as urbanization and UN-policies on SR.

**Teaching and Learning Methods:**
Discussion and creativity sessions. Project work evolving in a scientific paper for a journal of choice. Oral presentation.

**Media:**
Lectures, UN-policy notes, Discussion and Creativity sessions.

**Reading List:**
Tba

**Responsible for Module:**
van de Kuilen, Jan Willem; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Political and Social Perspectives of Renewable Resources (Vorlesung, 4 SWS)
van de Kuilen J [L], van de Kuilen J, Khaloian Sarnaghi A
For further information in this module, please click campus.tum.de or here.

# Module Description

## BV460017: Hydro Power und Energy Storage | Wasserkraft und Energiespeicherung

Version of module description: Gültig ab winterterm 2022/23

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

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

**Description of Examination Method:**
The module examination is a written exam (60 minutes, open book, allowed tools: notes, print medias (books, printed slides…), non-programmable calculator; not allowed tools: technical devices, communication). It consists of theoretical questions and practical calculations, each about 50%.

Furthermore, they prove that they can design a water power station in concept and dimensioning as well as the state-of-the-art technologies for energy storage.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Bachelor's level knowledge in hydraulic engineering, e.g.
• "Basic Module Hydraulic and Water Resources Engineering"
• "Supplementary Module Hydraulic and Water Resources Engineering"

**Content:**
The module provides in-depth knowledge of principles, methods and technologies for calculation and management of sustainable generation of energy from hydropower.

• types of hydro power stations, specific requirements of large and small hydro power
• elements of hydro power installations
• hydro turbines: turbine types, application ranges
• stream turbines: fundamentals, turbine types, application range
• energy conversion in hydro turbines - physical fundamentals

• planning of hydro power stations: hydrological surveys, layout, power plan
• needs and requirements for energy storage
• fundamental options for power storage
• properties of storage technologies, pros and cons, application ranges, potential, development state, project examples
• pumped storage plants: fundamentals, electromechanical equipment, new approaches

**Intended Learning Outcomes:**
After successful participation in the module, students will be able
• to describe, identify and assess established and newly proposed technologies of hydropower and energy storage
• to explain and assess the physical foundations of the energy conversion as well as the fundamental approach in planning hydropower projects
• to evaluate hydropower project plans and to perform planning themselves.

**Teaching and Learning Methods:**
• lecture style
• practical examples
• coordinated moodle tests (voluntary)

**Media:**
• PowerPoint presentations with film sequences and computer animations
• blackboard exercises
• moodle tests (voluntary)
• lecture notes in moodle

**Reading List:**
See lecture notes

**Responsible for Module:**
Prof. Dr. Nils Rüther (nils.ruether@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**
Hydro Power and Energy Storage (Vorlesung, 2 SWS)
Rüther N
For further information in this module, please click campus.tum.de or here.

# Module Description

## ED150010: Sustainable Mobile Drivetrains | Nachhaltige Mobile Antriebssysteme

Version of module description: Gültig ab winterterm 2022/23

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

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

**Description of Examination Method:**
Die Modulprüfung erfolgt in Form einer schriftlichen Klausur (Prüfungsdauer: 90 min). Die Studierenden sollen in begrenzter Zeit die Konzepte nachhaltiger mobiler Antriebssysteme auf verschiedene Frage- und Problemstellungen anwenden. Damit soll z. B. überprüft werden, ob die Studierenden bewerten können, wie eine konkrete Ausgestaltung eines Antriebssystems in verschiedensten Fortbewegungsmitteln ausgeführt werden kann oder ob die Studierenden die Grundlagen der Funktionsweise und des Aufbaus von Kolbenmotoren, elektrischen Antriebssträngen und von Antriebssträngen mit Brennstoffzelle verstehen.
Als Hilfsmittel zugelassen sind: Schreibutensilien, Lineal und ein nicht programmierbarer Taschenrechner.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
None

**Content:**
Themenschwerpunkte:
* Nachhaltigkeit und Klimaschutz
* Gestaltung nachhaltiger Mobilität
* Grundlagen der Fahrzeugtechnik
* Grundlagen der Fahrzeugantriebe
* Verbrennungsmotoren mit nachhaltigen Kraftstoffen
* Elektrische Antriebssysteme (Batterie, Inverter, e-Motor)
* Antriebssysteme mit Brennstoffzellen
* Energie und Mobilität

**Intended Learning Outcomes:**
Nach erfolgreicher Teilnahme am Modul "Nachhaltige Mobile Antriebssysteme" sind die Studierenden in der Lage...
... zu verstehen, wie und warum der Klimawandel eine Transformation hin zu nachhaltiger Mobilität erfordert
... einzuordnen, wie sich diese Transformation auf die traditionellen Verkehrsmittel und ihre Antriebe auswirken wird
... zu bewerten, wie eine konkrete Ausgestaltung eines Antriebssystems in verschiedensten Fortbewegungsmitteln ausgeführt werden kann
... die wichtigsten mobilen Antriebssysteme nach ihren jeweiligen Vorteilen, Nachteilen und Einsatzgebieten zu beurteilen
... die Grundlagen der Funktionsweise und des Aufbaus von Kolbenmotoren zu verstehen
... die Grundlagen der Funktionsweise und des Aufbaus elektrischer Antriebsstränge zu verstehen
... die Grundlagen der Funktionsweise und des Aufbaus von Antriebssträngen mit Brennstoffzelle zu verstehen
... einzuordnen, welches Antriebssystem für eine gegebene Anwendung am besten geeignet ist
... zu bewerten, welchen Einfluss die Rolle des Energieträgers auf die Nachhaltigkeit des gesamten Antriebssystems ausübt
... grundlegende Zusammenhänge zwischen Energie, Mobilität und Antriebssystem kritisch zu hinterfragen
... einfache aber wirkungsvolle Grobabschätzungen der wichtigsten Eigenschaften moderner Antriebssysteme vorzunehmen

**Teaching and Learning Methods:**
In der Vorlesung werden die Grundlagen nachhaltiger mobiler Antriebssysteme anhand von Vortrag, Präsentation und Tablet-PC vermittelt. Die Theorie wird durch Anwendungsfälle erläutert und mit Hilfe von einfachen Rechenbeispielen gefestigt. Erfahrungen und Probleme aus der Praxis werden vorgestellt, diskutiert und gerechnet.
Damit sollen die Studierenden beispielsweise lernen, zu bewerten, wie eine konkrete Ausgestaltung eines Antriebssystems in verschiedensten Fortbewegungsmitteln ausgeführt werden kann sowie die Grundlagen der Funktionsweise und des Aufbaus von Kolbenmotoren, elektrischer Antriebsstränge und von Antriebssträngen mit Brennstoffzelle zu verstehen.
Alle Lehrmaterialien sowie weiterführende Informationen werden kostenfrei in der Vorlesung verteilt oder werden online zur Verfügung gestellt. Sprechstunden werden flexibel angeboten.

**Media:**
* Vortrag
* Präsentation
* Tablet-PC mit Beamer
* Online-Lehrmaterialien

**Reading List:**
Zapf, Martin: Kosteneffiziente und nachhaltige Automobile. 2. Auflage. Wiesbaden: Springer Vieweg, 2021.

Doppelbauer, Martin: Grundlagen der Elektromobilität. Wiesbaden: Springer Vieweg, 2020.
Schreiner, Klaus: Verbrennungsmotor - kurz und bündig. Wiesbaden: Springer Vieweg, 2017.
Klell, Manfred: Wasserstoff in der Fahrzeugtechnik. 4. Auflage. Wiesbaden: Springer Vieweg, 2018.

**Responsible for Module:**
Jaensch, Malte; Prof. Ph.D.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Nachhaltige Mobile Antriebssysteme [ED150010] (Vorlesung, 3 SWS)
Jaensch M [L], Jaensch M, Heindl J
For further information in this module, please click campus.tum.de or here.

# Module Description

## ED160007: Lithium-Ion Battery Production | Lithium-Ionen-Batterieproduktion [VLBP]

*Lithium-ion battery production*

Version of module description: Gültig ab winterterm 2021/22

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

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

**Description of Examination Method:**
The module examination takes place in the form of a written exam (examination duration 90 minutes). By means of comprehension questions, calculation tasks and transfer tasks, the students should prove that they have an understanding of the basic processes of lithium-ion battery production and that they can apply this understanding. The content of the exam consists of comprehension questions from the lecture as well as various tasks, some of which are more advanced, based on the content of the exercises accompanying the lecture. Only a non-programmable calculator is allowed as an aid.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Prior experience in electrical energy storage and production engineering is recommended. Prior knowledge in chemistry and process engineering is not required but helpful.

**Content:**
The lecture provides an insight into all process steps in the production of lithium-ion batteries. The focus is on the holistic view of the process chain, including important process parameters and influencing factors.
Detailed content:
- Structure of the lithium-ion cell, electrochemical and electro-technical fundamentals, energy storage methods
- Material and cell systems on component level, process chains of battery production, safety aspects, production environment
- Mixing processes for anodes and cathodes (stirring, mixing)

- Coating processes for anodes and cathodes (slot die, doctor blade, cascade die) and process variants
- Calendering processes (porosity analysis, defect patterns)
- Packaging and assembling (cell formats, application areas)
- Packaging and contacting (ultrasonic welding, friction stir welding, laser welding)
- Filling and wetting (electrolyte properties, electrochemical impedance spectroscopy)
- Formation and aging (passivation layer, charge/discharge rate and lifetime test)
- Electrochemical characterization, cost models, quality criteria
- Recycling (material recycling, second life of the battery cell)
- Innovative process steps (laser patterning, mechanical prelithiation) and alternative lithium-ion battery technologies (solid-state batteries, sodium-ion battery)

**Intended Learning Outcomes:**
After participating in the module, students will be able to understand basic interrelationships of lithium-ion battery production and to evaluate them.
After successful participation in the module, students will be able to:
- Demonstrate a basic understanding of the material systems processed
- Evaluate the mode of operation of a lithium-ion battery on the basis of measurement characteristics
- Know, analyze and classify all process steps in lithium-ion battery production and their variants
- Understand basic interrelationships in lithium-ion battery production
- To develop requirements for the respective processes and suitable plant technology
- Evaluate typical fault patterns and assess their possible causes and consequences for the product
- Characterize the properties of a battery cell using cell tests and correlate them with the manufacturing processes
- Know, understand and apply important methods of quality assurance
- Understand future technologies and their special features with regard to the product and be able to recognize and classify trends

**Teaching and Learning Methods:**
In the lecture, the theoretical basics of lithium-ion battery production are taught by means of lecture and presentation. With the explanations from the lecture and corresponding self-study, the students learn to understand, evaluate and develop all process steps of lithium-ion battery production. Students supplement the course material by studying the recommended literature on battery production and related areas.
Students independently solve questions and tasks related to the content of the course using practical examples. In the exercise, sample tasks are calculated, discussed and debated together with the students. This is intended to ensure that the students can independently acquire the learning outcomes and transfer performance.

**Media:**
Presentations, videos and other illustrative material are used for visualization. Via the eLearning portal, the participants receive all exercise documents for preparation, which are then discussed

in the exercises. Furthermore, the lecture materials from the lecture are made available to the participants.

**Reading List:**
Recommended basic literature:
Korthauer, Reiner (Hrsg.): Handbuch Lithium-Ionen-Batterien. Springer-Verlag Berlin Heidelberg 2013. ISBN: 978-3-642-30653-2
Gulbinska, Malgorzata K. (Hrsg.): Lithium-ion Battery Materials and Engineering. Springer-Verlag 2014. ISBN: 1447165470
Julien, Christian (Hrsg.): Lithium Batteries, Science and Technology. Springer International Publishing 2015. ISBN: 9783319191089

In addition, further literature references are recommended in the individual lectures for in-depth study.

**Responsible for Module:**
Daub, Rüdiger; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Lithium-Ionen-Batterieproduktion (Vorlesung, 2 SWS)
Daub R [L], Daub R, Jaimez Farnham E, Lindenblatt J

Lithium-Ionen-Batterieproduktion (Übung, 1 SWS)
Daub R [L], Daub R, Lindenblatt J
For further information in this module, please click campus.tum.de or here.

## Module Description

### MW2245: Think. Make. Start. | Think. Make. Start. [TMS]

*Build innovative products of your ideas in 10 days!*

Version of module description: Gültig ab winterterm 2024/25

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

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

**Description of Examination Method:**
The module examination consists of a project work incl. written documentation (approx. 10 pages) and presentation (10 min), in which the students develop a new product in a group project and present their idea for founding a company on this basis. The individual performance is assessed to what extent the students are able to develop a product with market potential by means of an iterative approach to prototypical implementation. The assessment also includes the ability to work in a team, the ability to make well-founded design decisions and the completeness and conclusiveness of the concept, taking into account social relevance, novelty and innovation. As part of the project work, in addition to documentation, there is a final oral presentation. Through the presentation, students are expected to show whether they can demonstrate their ability to act as a competent team.

**Repeat Examination:**

**(Recommended) Prerequisites:**
The basic requirement is a willingness to engage with new learning methods, approaches, disciplines and ways of working. Cross-role experience in project management, product development (Design Thinking, TRIZ, Systems Engineering, etc), interdisciplinary teamwork, communication skills, creativity and problem solving skills are an advantage. A lot of emphasis is placed on practical experience.

For the "Problem Expert" role, experience in the following areas is an advantage:
- User Testing, Requirements Engineering, Interviewing, Human-Centered Design, Design, Visualisation, Use Case Definition, UX/UI Design, marketing, market research, benchmarking, design thinking.

For the "Tech Developer" role, experience in the following areas is an advantage:
- Hardware (mechanical): design, manufacturing (workshop/makerspace), prototyping, CAD/CAM.
- Hardware (electronic): embedded systems engineering, microcontrollers, sensors/actuators, Arduino, Raspberry, circuitry, board design, metrology, BUS protocols, prototyping, closed-loop/ open-loop control, robotics
- Software focus: Backend development, databases, frontend development, machine learning, web development, app development, embedded systems

For the "Business Developer" role, experience in the following areas is an advantage:
- Business Plan/Strategy/Design, Marketing, Sales, Interviewing, Finance & Accounting, Business Law & Regulations, Entrepreneurship.

The number of participants is limited and there will be an application process.

**Content:**
During the interdisciplinary team project, students work methodically, purposefully and agilely on a development project to develop innovative new products with the intention of successfully launching them on the market. Current needs and problems from social, technological and economic systems are identified, analysed and validated in the interdisciplinary team. In doing so, they cooperatively solve challenges that arise from constraints from the different disciplines. They generate suitable market hypotheses and product ideas at an early stage and interact with initial potential customers/users. They iteratively create prototypes and evaluate their hypotheses with them in experiments.

For more information, visit www.thinkmakestart.com and www.tms.tum.de.

**Intended Learning Outcomes:**
After participating in the module “Think.Make.Start.” the students are able to
- reproduce the principles of user-centered design
- apply methods of product development (e.g., Design Thinking) to a challenge of their choice
- develop important hypotheses involving relevant stakeholders (customer, user, ...) through proper planning with "purposeful prototyping"
- examine the relevance of a problem and develop a solution collaboratively in an interdisciplinary team
- design a prototype based on the acquired design methods and analyzed insights
- lay the foundation for one's own business start-up by identifying a start-up idea or team.

**Teaching and Learning Methods:**
"THINK. MAKE. START." is a two-week, practice-oriented, interdisciplinary and competitive teaching format in which students from all faculties can participate (credits are given individually related to the study program). It is organised by the different chairs of TUM, TUM ForTe, and UnternehmerTUM. They get access to the high-tech workshop Makerspace and budget to transform their own ideas into real prototypes (mechatronic products). Learning outcomes are achieved through the following teaching and learning methods:

- Milestones to be achieved, team roles to be held and predetermined course structure provide the roadmap for the project.
- Coaching and teaching expertise in prototyping, business validation, agile development, design thinking, systems engineering, lean startup and user-centred design.
- Teaching the basics of interdisciplinary collaboration through a role concept (Business Developer, Tech Developer, Problem Expert).
- All participants work in interdisciplinary teams (10 teams of 5 students each) and are encouraged to become active themselves and learn through practical experience (hands-on learning).
- Each team pursues a real business idea chosen for the seminar. Special attention is given to really understanding the customer and verifying the solution approach, through questioning, observation, prototyping or expert discussion.
- Using prototyping to bridge the gap between thinking and doing.
- Reflecting on one's own results and approach supports project decisions.
- The teams present their projects to a jury on DemoDay and present the prototypically implemented product ideas to guests from industry, the start-up scene and research.

**Media:**
Project manual, presentations, hand-outs, posters, videos, examples.

**Reading List:**
Esch Franz-Rudolf (2012) Strategie und Technik der Markenführung, 7. Auflage, Vahlen

Faltin, Günter (2008): Kopf schlägt Kapital, Hanser

Halgrimsson (2012): Prototyping and Model Making for Product Design (2012)

Kalweit Andreas, Paul Christof, Peters Sascha, Wallbaum Reiner (2012) Handbuch für Technisches
Produktdesign, Material und Fertigung, Entscheidungsgrundlage für Designer und Ingenieure, 2. Auflage, Springer

Kelly, Tom (2016): The Art of Innovation

Lindemann, U (2007): Methodische Entwicklung technischer Produkte - Methoden flexibel und situationsgerecht anwenden. 2. Auflage

Münchener Business Plan Wettbewerb: Handbuch Businessplan-Erstellung, München http://www.evobis.de/coaching/handbuch/

Malek, Miroslaw / Ibach, Peter K. (2004): Entrepreneurship, Dpunkt Verlag

Moore, Geoffrey A. (2002): Crossing the Chasm, Harpercollins

Osterwalder, Alexander / Pigneur, Yves (2010): Business Model Generation: A Handbook for

Ries, Eric (2011): The Lean Startup

Savoia, Antonio (2019): The right It

Timmons, Jeffry A. / Spinelli, Stephen (2009): New Venture Creation, 7thedition, McGraw, Hill Professional

UnternehmerTUM (2011): Handbuch Schlüsselkompetenzen, 7. Auflage

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

**Courses (Type of course, Weekly hours per semester), Instructor:**
Think.Make.Start. (Praktikum, 4 SWS)
Zimmermann M [L], Tong Y, Hohnbaum K, Amm M, Büchner B, Baur C, Bien S, Mogk J
For further information in this module, please click campus.tum.de or here.

## Module Description

### WZ1590: Climate Change Economics | Climate Change Economics

Version of module description: Gültig ab summerterm 2024

| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
|---|---|---|---|
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
There will be a written exam (Klausur) of 90 minutes at the end of the semester. The students will be asked to demonstrate, within the stipulated amount of time using predefined methods and resources, their ability to outline the challenges climate change poses to regulators, propose pragmatic solutions and strategies as well as ways of implementing them. This will be based on the competencies acquired from the relevant literature of economic modeling, theories of climate change, and their understanding of the course content. The written exam is an appropriate assessment method to evaluate the degree to which the students understand the theoretical framework of climate change implications as well as provides an opportunity for them to put forward arguments based on existing theory.

In addition, there is the option of taking a voluntary mid-term assignments as course work in accordance with APSO §6, 5. For this, a presentation (15 min) has to be given.
The module grade can be improved by 0.3 by passing the course work if this better characterises the student's performance level on the basis of the overall impression and the deviation has no influence on passing the examination. No repeat date is offered for the mid-term performance.
When retaking a failed module examination at the next possible examination date, successfully passed mid-term assignments will be taken into account.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge:
• Micro Economics (Welfare Economics)
• Environmental Economics
• Resource Economics

**Content:**
This course covers the trends in current and future climate change and their effects on economic and social outcomes.

The lectures cover the following topics:
1. Introduction to the Basic Science of Climate Change
- The students will learn about the scientific themes of global climate change and the economic dimension of the phenomenon.
2. Basic Economics
- The students will learn how a market economy can be efficient and socially optimal as well as about the prospects of externality.
3. Optimal Emission Levels
- The students will learn of the optimal abatement path and its uncertainty with respect to damages as well as Integrated Assessment Models (IAMs).
4. Intra-generational equity in climate policy
- The students will learn about how to account for equity across space (intergenerational equity) when deriving optimal emission levels.
5. International Environmental Agreements
- The students will learn about the dynamics behind common strategies towards achieving some form of optimal emission level.
6. Policy Instruments
- The students will learn about diverse instruments such as quality-based approach and Pigouvian Tax.
7. Regulation via Prices vs. Quantities
- The students will learn what circumstances will a regulator prefer prices over quantities and vice versa.
8. Credit-based Mechanisms
- The students will learn about how to deal with countries that do not want to commit but have a high potential for low-cost reductions.
9. German Climate Policy
- The students will learn about German Climate Action - strategies and policies
10. European Union Emission Trading Scheme - EU ETS

**Intended Learning Outcomes:**
After successfully completing the module, students are able to:
• Evaluate economic models related to climate change.
• Understand theoretical models of climate change regulations as well as policies that affect emission levels.
• Comprehend the complexity, uncertainty and possibilities associated with optimal emission level.
• Analyze appropriate instruments for emission levels that are efficient and cost-effective.
• Understand different forms of climate agreements and climate action strategies that are currently being implemented

**Teaching and Learning Methods:**
The course consists of lectures (2 SWS) and seminars (2 SWS). The lecture forms the basis for the subsequent discussion within the seminar on climate change issues from an economic perspective. The content of the module is expected to be transferred to the students in an interactive learning manner (including discussions in the lectures but especially intensive discussions in the seminar) where, among others, emission reduction instruments are scrutinized. This encourages the students to independently and self-reliantly study the literature guided by a structured framework.

**Media:**
PowerPoint, flipchart, internet portals, online reports etc.

**Reading List:**
Bréchet, T., & Eyckmans, J. (2009). Coalition theory and integrated assessment Modelling: Lessons for climate governance. Global Environmental Commons: Analytical and Political Challenges in Building Governance Mechanisms.
Rohling, M., & Ohndorf, M. (2012). Prices vs. quantities with fiscal cushioning. Resource and Energy Economics, 34(2), 169-187.
MacKenzie, I. A., & Ohndorf, M. (2012). Optimal monitoring of credit-based emissions trading under asymmetric information. Journal of regulatory economics, 42(2), 180-203.
Hake, J. F., Fischer, W., Venghaus, S., & Weckenbrock, C. (2015). The German Energiewende–history and status quo. Energy, 92, 532-546.
Climate Action Plan 2050 Principles and goals of the German government's climate policy. https://www.bmu.de
/fileadmin/Daten_BMU/Pools/Broschueren/klimaschutzplan_2050_en_bf.pdf
EU ETS Handbook. https://ec.europa.eu/clima/sites/clima/files/docs/ets_handbook_en.pdf

**Responsible for Module:**
Sauer, Johannes; Prof. Dr. agr.

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

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

## Sustainable Management | Sustainable Management

## Specialization in Engineering and Natural Sciences | Specialization in Engineering and Natural Sciences

# Module Description

## CS0102: Introduction to Game Theory | Introduction to Game Theory [IGT]

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
Learning outcomes are verified in a written exam (90 minutes). Students show the extent to which they have understood the taught game-theoretical definitions and terminology. They show to which extend they are able to use games in order to model problems from economics and engineering. They are also expected to apply important solution concepts to concrete games and answer comprehension questions concerning the properties and the advantages and disadvantages of the different solution concepts.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Module Mathematics (WZ1601) or Advanced Mathematics 1 (CS0175)

**Content:**
Cooperative and non-cooperative games, solution concepts for cooperative games, core, Shapley value, solution concepts for non-cooperative games, pure Nash equilibria, mixed Nash equilibria, dominant strategies, Bayesian games, modeling concrete case studies related to sustainability as cooperative and non-cooperative games

**Intended Learning Outcomes:**
Students have aquired basic theoretical and practical knowledge on cooperative and non-cooperative games. They know the basic definitions and terminology and are able to model sustainability-related problems from economics and engineering as games. Students know the most important solution concepts for cooperative games (such as the core and the Shapley value) and non-cooperative games (such as Nash equilibria and dominant strategies). They have gained a good understanding of these concepts and are able to analyze concrete games by using them.

**Teaching and Learning Methods:**
Lectures introduce basic knowledge; tutorials practice modelling of application problems as games and applying solution concepts to concrete examples.

**Media:**
Lectures given as presentations (projector and/oder blackboard), tutorials with group work and exercise sheets

**Reading List:**
Manfred J. Holler, Gerhard Illing, Stefan Napel - Einführung in die Spieltheorie, 8. Auflage, Springer Gabler, 2019.
Steven Tadelis - Game Theory: An Introduction, Princeton University Press, 2013.
M. J. Osborne and A. Rubinstein - A Course in Game Theory, MIT Press, 1994

**Responsible for Module:**
Thielen, Clemens; 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

## WZ1193: Biogas Technology | Biogastechnologie [BiGA]

Version of module description: Gültig ab summerterm 2024

| **Module Level:** Master | **Language:** English | **Duration:** one semester | **Frequency:** summer semester |
|---|---|---|---|
| **Credits:*** 5 | **Total Hours:** 150 | **Self-study Hours:** 100 | **Contact Hours:** 50 |

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

**Description of Examination Method:**
Students take a written examination (90 minutes) to demonstrate their knowledge of microbial breakdown processes in the biogas process, as well as their ability to assess influencing factors. They also demonstrate their knowledge of various technologies for using biogas and can explain their respective advantages and disadvantages. Additionally, they demonstrate that they have understood the legal and economic framework conditions  of biogas technology and are able to translate these to case examples. Students also show that they can develop basic concepts of biogas plants.They will answer questions on the topic in their own wording and explain case examples or work out calculations. Multiple-choice questions are also possible.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Required: basic knowledge in biology, especially microbiology, as well as general and organic chemistry, mathematics, physics and thermodynamics of cycles; of advantage: knowledge in agriculture and agricultural engineering

**Content:**
Microbiology of biogas processing, anaerobic substrate breakdown, factors influencing the fermentation process, process management strategies, biogas storage and purification; biogas recovery (e.g. use of a motor for power generation with or without the use of heat or feeding into the gas grid); legal-economic framework conditions; sustainability issues; competition for raw material and acceptance of biogas plants; aspects of biogas plant design.

**Intended Learning Outcomes:**
After successful completion of the module, students are able to develop concepts for biogas generation and recovery in a specific context. Students are aware of microbial breakdown

processes in biogas plants and can differentiate between various influencing factors. They are also aware of various processes for the use of biogas and understand their advantages and disadvantages. Students recognize the meaning of biogas technology for sustainable energy supply. Students have a good knowledge of legal and economic framework conditions in the field of biogas generation and they are able to conceptualize basic biogas plants.

**Teaching and Learning Methods:**
Lectures given as presentations, with the help of a blackboard and interactive elements, in particular group work on case examples; optional: excursion to a biogas plant to deepen acquired knowledge in a real-life setting

**Media:**
PowerPoint presentation, slide notes, exercise sheets

**Reading List:**
D. Deublein, A. Steinhauser, Biogas from Waste and Renewable Resources - An Introduction, Wiley-VCH, 2010,  ISBN-13: 978-3-527-32798-0, ISBN-10: 3-527-32798-3

**Responsible for Module:**
Doris Schieder (doris.schieder@tum.de)

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

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

## Module Description

### CS0100: Microbial and Plant Biotechnology | Microbial and Plant Biotechnology [MPBioTech]

Version of module description: Gültig ab summerterm 2023

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

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

**Description of Examination Method:**
In order to check whether students have understood and are able to apply the principles and relevant methods and techniques of biotechnological production processes, the students answer questions about production processes and fermentation strategies, as well as on important methods and applications in plant biotechnology in a written exam (90 min) and prove that they have understood the correlations of metabolism. Allowed tools are calculators.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Fundamentals of Biology or of cell and microbiology from the Bachelor's courses

**Content:**
In the lecture microbial biotechnology relevant topics and techniques of microbial biotechnology are presented. This includes the quantitative description of the metabolic performance of microorganisms, industrially relevant substrate sources, metabolic engineering strategies as well as examples of industrial production processes (e.g.: alcohols, amino and organic acids).
In the lecture plant biotechnology the most important model and crop plants in biotechnology are presented, classified and their morphological and physiological properties are emphasized. Major questions, methods and solutions will be discussed with thier pros and cons. Some of the topics to be discussed: legal framework, major appilcation of current plant genetic engineering, the Arabidopsis model system, snovel concepts for yield and quality improvement. One focus is on the challenges for agriculture caused by climate change and sustainable solutions.

**Intended Learning Outcomes:**
Upon successful completion of the module, students will be familiar with the principles and techniques of relevant microbial bioprocesses. The students have acquired knowledge of fermentation processes and are able to develop strategies for process control for selected product classes. The students have learned to quantitatively describe microbial growth and fermentation processes. The students have acquired in-depth knowledge of relevant production processes for selected products of industrial biotechnology and understand their importance for the development of sustainable chemistry. Also, the students know the most important methods and applications in plant biotechnology and are able to assess them.

**Teaching and Learning Methods:**
The contents of the lectures are conveyed by a talk of the lecturer, based on PowerPoint presentations. The blackboard might additionally be used to explain more complex relationships. To a limited extent, this can be supplemented by self-study of the literature mentioned in the lecture.

**Media:**
PowerPoint, whiteboard

**Reading List:**
Microbiology – an evolving science, J. L. Slonczewski, J. W. Foster, W W Norton & Co Inc, 4th edition, ISBN: 978-0-393-61403-9 (available in the library)
Molecular Biology of the Gene, I. D. Watson, T. A. Baker, A. Gann, M. Levine,
Losick, Pearson, 7th edition, ISBN-13: 978-0321762436 (available in the library)
Biotechnology, R. D. Schmid, C. Schmidt-Dannert, Wiley-VCH, 1st edition,
ISBN: 978-3-527-33515-2 (available in the library, eBook)
Industrial Microbiology, D. B. Wilson, H. Sahm, K.-P. Stahmann, M. Koffas,
Wiley-VCH, 1st edition, ISBN: 978-3-527-34035-4 (available in the library)
Industrial Biotechnology – Products and Processes, C. Wittmann, J. Liao,
Wiley-VCH, volume 4, ISBN: 978-3-527-34181-8 (available in the library, eBook)
Industrial Biotechnology – Microorganisms, C. Wittmann, J. Liao,
Wiley-VCH, volume 4, ISBN: 978-3-527-34179-5 (available in the library, eBook)
Campbell Biology N. A. Campbell, L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky, J. B. Reece, Pearson, 11th edition (2018) (available in the library)

**Responsible for Module:**
Blombach, Bastian; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Microbial Biotechnology (Vorlesung, 2 SWS)
Blombach B [L], Blombach B

Applied Microbiology and Metabolic Engineering (Lecture) (Vorlesung, 2 SWS)
Blombach B [L], Blombach B, Glawischnig E

Plant Biotechnology (Lecture) (Vorlesung, 2 SWS)
Glawischnig E [L], Glawischnig E
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0012: Artificial Intelligence for Biotechnology | Artificial Intelligence for Biotechnology [AI]

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The module examination takes the form of a presentation followed by discussion. The learning outcomes are verified by a group project (3-4 students per group). The presentation of the developed code and the results of the project will be done together as a group, with each group member presenting one part. The presentation should be equally divided among the group members. After the presentation, each group member is asked individual questions about the project. The final grade will be based on the presentation and results of the project (duration of presentation and questions: approx. 30 min depending on group size; approx. 8-10 minutes per student). As a voluntary mid-term effort, the students can take part in a multiple-choice test (duration: 10 minutes). If they achieve at least 65% of the points in this test, a bonus of 0.3 will be credited on the grade of the presantation (however, an improvement of the grade from 4.3 to 4.0 is not possible).

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Mathematical Skills in Linear Algebra and Statistics as well as Programming Skills in Python are expected

**Content:**
Technologies that generate analyses or predictions based on data can be found in almost all areas of our daily life (e.g. recommender systems, autonomous driving, and credit card fraud detection). These methods are also important for analyzing biological and biomedical data, e.g. for finding novel patterns in biological data, predicting the disease state of a patient, or the 3D structure of proteins. In this course, we will learn the fundamentals of machine learning and will apply these methods to various real-world problems.

The following contents will be treated exemplarily:
- Similarity and Distance Metrics
- Data Preprocessing and Visualization
- Dimensionality Reduction (e.g., Principal Component Analysis)
- Classification (Nearest-Neighbor, Logistic Regression, Decision Trees, Support Vector Machines (SVM))
- Model Selection and Hyperparameter Optimization (Confusion Matrix and Evaluation Measures, Cross-Validation, Hyperparameter tuning techniques, Common problems such as Over- vs. Underfitting)
- Clustering (K-Means, Hierarchical Clustering)
- Regression Models (Linear Regression, Support Vector Regression)

AI-based technologies have the potential to support many areas of biotechnology and sustainability, e.g. by guiding downstream research with data-driven predictions or supporting decision-making with demand forecasts. In this course, we will look at suitable practical examples and demonstrate their potential.

**Intended Learning Outcomes:**
The students know the fundamental and most important artificial intelligence, especially machine learning, methods and are able to apply them independently on various real-world problems. The students learn the basics of the programming language Python (one of the leading programming languages in the field of machine learning) and are able to implement and apply machine learning algorithms in Python. In addition, students are able to visualize and interpret different types of data and results independently. Students will understand how artificial intelligence can support areas of biotechnology and sustainability and are able to assess the potential of AI-based approaches in sustainability projects.

**Teaching and Learning Methods:**
Lectures to provide the students with all necessary fundamentals of artificial intelligence, especially of machine learning which they will need to independently apply these concepts to real-world data. In the exercises the students are introduced to the programming language Python, as well as to apply and implement these algorithms for specific case studies.

**Media:**
The lecture shall mainly be done by using PowerPoint presentations. During the exercise the students work at PCs to gain confidence in using the programming language Python. Students implement various machine learning methods in Python (e.g. using Jupyter Notebooks) and apply them on various examples. Students work on real world problems to implement learnt skills and to gain confidence in applying these different methods independently.

**Reading List:**
Murphy, K. P. (2012). Machine learning: a probabilistic perspective. MIT press.
Bishop, C. M. (2006). Pattern recognition and machine learning. Springer.
Raschka, S. (2017). Machine Learning mit Python. mitp Verlag.

Friedman, J., Hastie, T., & Tibshirani, R. (2001). The elements of statistical. Springer.

**Responsible for Module:**
Grimm, Dominik; 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

### CS0105: Modelling and Optimization of Energy Systems | Modelling and Optimization of Energy Systems [MOES]

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Assessment is done in a written examination (90 minutes). Participants of the course solve programming tasks to demonstrate that they are able to apply the methods aquired in the course. By answering questions related to case examples they show that they have learned to put things into their proper context.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Bachelor modules Mathematics, Physics, Numerical Methods;
Basic knowledge in Energy technology; basic programming experience (ideally with Matlab)

**Content:**
Basics of Modelling and Simulation:
- physical models
- data-based models (look-up tables, polynomials, neural networks)
- methods for generating models
Fundamental optimization methods:
- linear optimization (linear regression)
- nonlinear optimization

**Intended Learning Outcomes:**
After attending the course the participants understand basic methods for creating models, simulation and optimization. In addition, they are able to apply these methods by creating appropriate program code in Matlab. Furthermore, the participants acquire Matlab programming experience.

**Teaching and Learning Methods:**
The module consists of a lecture and an excercise. Lectures include presentations whose content is deepened by solving excercise problems autonomously. In order to improve the learning outcome, participants work at homework excercise problems. These are discussed in the next lecture.

**Media:**
PP presentation, whiteboard, demonstration of programs

**Reading List:**
S. R. Otto & J.P. Denier, An Introduction to Programming and Numerical Methods in MATLAB, Springer, London, 2005
O. Nelles, Nonlinear System Identification, Springer, Berlin, 2010

**Responsible for Module:**
Kainz, Josef; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Modelling and Optimization of Energy Systems (Vorlesung mit integrierten Übungen, 4 SWS)
Kainz J [L], Kainz J
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0101: Renewables Utilization | Renewables Utilization

Version of module description: Gültig ab winterterm 2020/21

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Assessment takes a written examination (90 minutes), with students to unterstand and to apply structure, transformation and use of different renewable resources. Students are required to answer questions using individual formulations and outline structures and reactions. In addition, sample calculations are to be worked out.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic lectures in chemistry; Basics on renewables utilization

**Content:**
Various types of ingredients of renewable raw materials: sugars, polysaccharides, fats and oils, amino acids, proteins, terpenes, aromatics. The following topics will be dealt with in more detail: structure, composition, occurrence, properties, analysis and type of added value or use in various examples.

**Intended Learning Outcomes:**
After completion of the modules, students understand the chemical composition of renewable resources as well as their production and application. Using this knowledge students are able to explain the respective advantages and disadvantages as well as analyze the underlying physical, chemical and biotechnological principles of their conversion into valuable products.

**Teaching and Learning Methods:**
Lecture and accompanying tutorial including individual work on specific examples.

**Media:**
Presentation, script, examples and solutions

**Reading List:**

**Responsible for Module:**
Rühmann, Broder; Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Renewables Utilization (Exercise) (Übung, 2 SWS)
Rühmann B

Renewables Utilization (Lecture) (Vorlesung, 2 SWS)
Sieber V [L], Rühmann B, Sieber V
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0009: Enzymatic Biotransformations | Enzymatic Biotransformations [IBT]

Version of module description: Gültig ab winterterm 2023/24

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
The students should be able to understand and describe possibilities and limitations of established industrial enzymatic processes. This understanding and its application to derive ways to improve existing processes, making them more sustainable and to establish new ones, a written examination takes place with a duration of 90 minutes (approved tool: calculator). As a voluntary mid-term effort, the students can take part in three online test within the Moodle course of the exercise. If they achieve at least 65% of the points in these tests, a bonus of 0.3 will be credited on the grade of the written examination (however, an improvement of the grade from 4.3 to 4.0 is not possible).

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
The lecture provides a broad overview about applications of enzymes in industrial processes and detailed insight into the corresponding technically important aspects by means of current examples. Essential contents are: industrially relevant properties of enzymes, essential enzyme classes and the most important enzymatic mechanisms, whole cell catalysis vs. enzyme catalysis, biocatalysis vs. classical chemical catalysis, methods of enzyme immobilization, enzymes in aqueous and non-aqueous systems, enzymatic reactions combined with chemical reactions, large-scale supply of enzymes. On the application side, biotransformations which are necessary for the conversion of biogenic ressources are treated as well as reactions for the synthesis of bulk chemicals, fine chemicals and food additives.

**Intended Learning Outcomes:**
After participating in the lecture the students will be able to review possible applications of enzymes in different chemical and technical processes, to understand the behaviour and limitation of enzymes in these processes and to derive ways to establish new reactions biocatalytically and to propose technically meaningful scenarios for newly developed enzymatic processes respectively.

**Teaching and Learning Methods:**
The lecture will be performed as ex-cathedra teaching which is interrupted by queries to familiarize students with all necessary basics and to stimulate independent, critical thinking. In the exercise, the students will deepen the knowledge they have learned and solve specific problems of varying complexity, either alone or in group work.

**Media:**
PowerPoint, white board, exercise sheets or online questions

**Reading List:**

**Responsible for Module:**
Sieber, Volker; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Enzymatic Biotransformations (Exercise) (Übung, 1 SWS)
Sieber V [L], Arana Pena S, Hupfeld E

Enzymatic Biotransformations (Lecture) (Vorlesung, 2 SWS)
Sieber V [L], Sieber V
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0086: Wood-based Resources | Wood-based Resources

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Exam achievement shall be done in the form of a test. Product pathways of forestry and forest industry shall be reflected here. Classification of economic and ecological aspects of forestry and forest industry from cultivation to material and energetic use shall be explained by using examples of particular cases. Recognition of wood and wood materials shall be shown. The relation of knowledge of forestry and forest industry with regard to knowledge of different woods and wood utilisation will be evaluated at a ratio of 1 to 1. The answers require own formulations from the respective technical jargon of forestry and forest industry.
Type of exam: In writing. Exam duration: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**

**Content:**
The module aims at providing in-depth knowledge to the students in the field of forestry and forest industry from harvest to the use of wood. Special emphasis is given to the interfaces concerning wood use (sawing, wood materials and paper industry) and energy wood production. In a further aspect differences of woods shall be addressed from a microscopic point of view through to their field of application in the manufacturing industry. Therefore, students learn to classify woods microscopically and macroscopically.

**Intended Learning Outcomes:**
After attending the module the student shall be able to characterise the product pathways in forestry from crop establishment through to material and energetic use of wood. He distinguishes different forms of economy and is able to classify them according to economic, social and

ecological aspects. He recognises differences of woods, knows various new products produced from wood and understands their production paths and their markets.

**Teaching and Learning Methods:**
The course attendance of forestry and wood consists of a lecture and exercises. For this purpose powerpoint presentations amd practical training material shall be used. A study trip to wood processing plants including lectures from qualified personnel providing information from experience on site with common rounds of questions provides in-depth knowledge of the production paths. A socalled wood block determination, i. e. the determination of wood by means of different genuine wood samples, will be performed by a magnifying glass 10x.

**Media:**
The following forms of media apply: Script, powerpoint, films, for determination exercises also branches and leaves of shrubs to be determined. Study trip to companies with guided tour of processing and treatment of wood. Determination of wood with a magnifying glass 10x.

**Reading List:**
D. Fengel and G. Wegener: Wood. Publisher: De Gruyter, https://doi.org/10.1515/9783110839654
Jörg van der Heide, 2011: Der Forstwirt. (The Forester) Publisher: Ulmer (Eugen); Auflage: 5th edition. (September
26, 2011)
Language: German
ISBN-10: 3800155702
ISBN-13: 978-3800155705; D. Fengel, G. Wegener: Wood Verlag Kessel, www.forstbuch.de

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Wood-based Resources (Exercise) (Übung, 2 SWS)
Zollfrank C [L], Röder H, Zollfrank C

Wood-based Resources (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Röder H, Zollfrank C
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0026: Advanced Concepts of Bioinformatics | Advanced Concepts of Bioinformatics

Version of module description: Gültig ab winterterm 2023/24

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Learning outcomes shall be verified in a written test. Tasks shall be specified by means of which the students are to demonstrate that they know the bioinformatic methods imparted as part of the module and that they have understood and are able to apply them for specific case studies. Exam duration: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Module Biochemistry, WZ1631 Bioinformatics, CS0001 Foundations of Computer Science, Knowledge Linux Command Line Interface, Programming Skills in Python

**Content:**
In this course state-of-the-art methods in statistical genetics, genome-wide association studies, analysis of complex biological networks, protein-analysis as well as modern machine learning methods for genomic data are investigated and applied on various case-studies.

**Intended Learning Outcomes:**
The students know state-of-the-art bioinformatics methods and are able to apply them independently on various real-world problems. The students lern to implement custom Python scripts to analyse, visualise and interprete the results of these methods independently.

**Teaching and Learning Methods:**
Lectures to provide the students with the theoretical and practical concepts of state-of-the-art bioinformatics methods, which they will need to independently apply these methods on real-

world data. In the exercises the students will apply these tools on concrete case studies and will implement custom Python scripts to analyze, visualize and interpret the results.

**Media:**
The lecture shall mainly be done by using PowerPoint presentations. During the exercise the students work at PCs to gain confidence in using the bioinformatics tools. Students implement various custom Python scripts (e.g. using Jupyter Notebooks) to analyze, visualize and interpret the results of these tools. Students work on real world problems to implement learnt skills and to gain confidence in applying these different methods independently.

**Reading List:**
Pevsner, J. (2017). Bioinformatics and functional genomics. Wiley Blackwell.

**Responsible for Module:**
Dominik Grimm

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

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

# Module Description

## CS0134: Conceptual Process Design | Conceptual Process Design

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
The exam performance is effected by an oral exam. It is reviewed whether the students know the fundamentals of conceptual design of chemical and biotechnological processes and if they can apply this knowledge on the design and evaluation of complex processes. The exam consists of two parts: (a) 30 minutes preparation through solving a given problem set (b) 30 minutes of oral examination. In the beginning of part (b) the results of part (a) are presented by the student. (total duration 60 min)

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Knowleadge of thermodynamics and apparatusses used for fluid sparations processes. It is recommended to visit at least the course "Introduction of Process Engineering" first.

**Content:**
Basics of cenceptual design of processes; Basics of computational process design including calculation of process parameters; transfer of fundamental scale-up criteria towards real problem solving; Balancing of all process streams; Deepened knowledge of engineering principles.

**Intended Learning Outcomes:**
The students are qualified to understand the fundamentals of design, calculations, and balancing of chemical processes and fluid separation courses after the course. They will aquire knowledge of different challenges of process design and how to master them.

**Teaching and Learning Methods:**
The module consists of lectures and parallel tutorials. Contents of the lecture shall be imparted in speech and by presentation. In the exercises performed as part of the module learned theory

shall directly be applied with a practical orientation by means of calculations and examples from targeted aspects of process design and calculation. based on a direct comparison of a chemical process with it´s biotechnical alternative they learn to apply their knowledge on reality based challenges. Additionally they will be qualified by an in-depth knowledge of the design of operation units including calculation of process parameters based on utilization of selected software tools.

**Media:**
Panel, slides, scripts, practical exercises

**Reading List:**
Moulijn et al. (2013). Chemical Process Technology. – John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, United Kingdom.
# Biegler et al. (1997). Systematic Methods of Chemical Process Design. – Prentice Hall.
# Doherty, M.F., Malone, M.F. (2001). Conceptual design of distillation systems. – Boston: McGraw-Hill.
# Gmehling, J., Kolbe, B., Kleiber, M., Rarey, J. (2012). Chemical Thermodynamics for Process Simulation. 1. Auflage. Weinheim: Wiley – VCH
# Grassmann, P., Widmer, F., Sinn, H. (1997). Einführung in die Thermische Verfahrenstechnik. 3. vollst. überarb. Auflage. Berlin: de Gruyter.
# Stichlmair, J.G., Fair, J.R. (1998). Distillation: Principles and Practice. – New York: Wiley – VCH.

**Responsible for Module:**
Burger, Jakob; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Conceptual Process Design (Lecture) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Ibanez M, Staudt J

Conceptual Process Design (Exercise) (Übung, 2 SWS)
Burger J, Rosen N, Wolf A
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0170: Advanced Modelling and Optimization | Advanced Modelling and Optimization

Version of module description: Gültig ab winterterm 2021/22

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>German/English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The examination is based on two project works (each 50% of evaluation).

The project works examine the understanding of the modeling and programming techniques discussed in the course. The project works includes, appling algorithms to solve problems, creating mathematical models for examplary problems, and discuss presented results. By this the students have to demonstrate that they have understood and can apply the mathematical models and methods to solve planning problems. The project paper serves the assessment of the understanding of the modeling and programming language.

For the project paper the participants get a randomly assigned fictive, extensive decision problem. For this problem, the following has to be prepared:
- a modeling of the problem as a mathematical program, as well as explanation of the program
- an implementation of the program in a known optimization and programming language
- a verbal and graphical explanation of the of the results for the original problem

The grading of the project paper is done by the following criteria:
- Correctness of modeling and implementation as well as of the results (60% of examination)
- Clarity, comprehensibility and efficiency of the implementation (30% of evaluation)
- correct language, typesetting and outer form of the paper (10% of evaluation)

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Operations Research (CS0098)

**Content:**
This course is about modeling, solving and analyzing planning and decision problems using mathematial concepts. The course teaches the basics of linear, discrete and dynamic optimization. In addition, there is an introduction to optimization and corresponding programming languages, as well as teaching methods for analyzing and structuring algorithms, designing suitable object-oriented data structures, applying known standard algorithms and connecting them to other resources and programming environments.

**Intended Learning Outcomes:**
After successful completion of the module students are capable of modelling planning problems. Students learn to model real life business problems by applying mathematical programming techniques. They can independently implement mathematical models by using an optimization language and heuristical approaches. They are able to solve the models within the scope of a case study and can interpret the results. Furthermore, they deepen their knowledge in several different modeling techniques and basics of object oriented programming.

**Teaching and Learning Methods:**
The module consists of a lecture and exercise courses, which are provided weekly. In the lecture the content is jointly developed with the students mainly by using slides. The exercise course repeats parts of the lecture contents by using examples and offering the opportunitis to implement poblems individually. The excercises give the student the opportunity to pose questions and receive immediately help from the teaching assistant.

**Media:**
Script, Presentation slides

**Reading List:**
Hilier, F. and Lieberman, G., Introduction to Operations Research, McGraw-Hill, 2009
Popp, Andreas: Modellierung und Optimierung mit OPL. epubli, 2015
Schildt, H.: Java, A Beginner's Guide, 5th Edition, McGraw-hill, 2011
Winston, W.: Operations Research - Applications and Algorithms. 4th ed. (internat. student ed.), Belmont, Calif. (Duxbury), 2004.

**Responsible for Module:**
Alexander Hübner alexander.huebner@tum.de

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

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

# Module Description

## CS0003: Production of Renewable Fuels | Production of Renewable Fuels

Version of module description: Gültig ab winterterm 2023/24

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The learning results are going to be proven in form of a written exam of 90 Minutes. Along the problem set, it is checked whether the student is able to understand, improve and assess industrial processes for the production of renewable fuels. No aids permitted.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basic knowledge in chemistry, Fundamentals in Thermodynamics (e.g., Grundlagen der Thermodynamik), Fundamentals in Process Engineering (e.g., Introduction to Process Engineering)

**Content:**
Requirements for fuels, linkage of energetic and chemical value chains, fossil fuel production as reference, balancing and assessments (Well-to-Wheel), Hydrogen and methanol economy, alternative fuels on C1-basis, fisher-tropsch fuels, OME, bio-based oil fuels, biodiesel, green diesel, HEFA, bio-based alcohols, legislation of fuels.

**Intended Learning Outcomes:**
This module aims at making the students familiar with the industrial processes to produce renewable fuels. They are able to set up material and energy balances of these processes and assess their sustainability. Limitations with respect of raw material supply, energetic efficiencies and market requirements are understood. The students understand the interactions of fuel market and energy market.

**Teaching and Learning Methods:**
The module consists of a lectures and exercises. Contents of the lecture shall be imparted in speech and by presentation. To deepen their knowledge students are encouraged to study the literature and examine with regards to content the topics. In the exercises learned theory is applied with a practical orientation by means of arithmetic examples.

**Media:**
Hybrid live lectures & asynchronous mini-videos allowing distance learning, lecture Script and exercises via online platform, excursions to fuel production plants

**Reading List:**
• Jacob A. Moulijn, Michiel Makkee, Annelies E. van Diepen: Chemical Process Technology, Wiley (2013).
• George Olah et al.: Beyond Oil and Gas: The Methanol Economy, Wiley VCH (2006)
• Volker Schindler: Kraftstoffe für morgen: Eine Analyse von Zusammenhängen und Handlungsoptionen, Springer (1997)
• Martin Kaltschmitt, Hans Hartmann, Hermann Hofbauer: Energie aus Biomasse; Grundlagen, Techniken und Verfahren,SpringerVieweg (2016)
• Jochen Lehmann, Thomas Luschtinetz: Wasserstoff und Brennstoffzellen, Springer (2014)

**Responsible for Module:**
Burger, Jakob; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Production of renewable fuels (Tutorial, Straubing) (Übung, 2 SWS)
Burger J [L], Burger J, Groh D, Rosen N

Production of renewable fuels (Tutorial, Garching) (Übung, 2 SWS)
Burger J [L], Burger J, Groh D, Staudt J

Production of renewable fuels (Lecture, Straubing) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Staudt J

Production of renewable fuels (Lecture, Garching) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Staudt J
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0008: Enzyme Engineering | Enzyme Engineering [EE]

Version of module description: Gültig ab summerterm 2022

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
To proof whether the students are able to show ways to optimize enzymes in their properties and to perform this methodically, a written examination takes place with a duration of 60 minutes and a written seminar report must be created.The total grade consists of the written exam grade (67%) and the grade of the seminar report (33%).

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
This course aims to convey molecular biology and protein chemistry approaches to optimize enzymes especially by variation of the primary structure. Essential contents are: analysis of the limitation at the molecular level, rational methods, computer-based methods, evolutionary and combined procedures, high-throughput methods, robotics. The seminar aims to convey basic bioinformatical tools used in rational enzyme design such as ligand docking, energy minimization and rational introduction of mutations. These methods will be practiced on real enzymes and used to generate improved enzyme variants for a specific engineering target.

**Intended Learning Outcomes:**
After participating in the lecture the students will be able to indicate options for the improvement of technically limited enzymes, to estimate the necessary effort for these improvements and they own the theoretical ability to put these improvements into practice. After having participated in the seminar the students are able to use different bioinformatical tools for rational enzyme design and are able to evaluate the results of the generated informatical predictions.

**Teaching and Learning Methods:**
The lecture will be performed as ex-cathedra teaching to provide the students with all necessary fundamentals. In addition, the students review single methods and procedures by themselves e.g. based on current scientific literature and present this review to each other in a presentation. In the seminar, the students will be guided through the single steps of a rational enzyme engineering approach with the help of a script. The results of these steps will be summarized in a written report to put the single steps into a larger context.

**Media:**
PowerPoint, lecture script, scientific publications

**Reading List:**
Recommendations:
"Directed Enzyme Evolution: Screening and Selection Methods” (Methods in Molecular Biology) and “Directed Evolution Library Creation: Methods and Protocols” (Methods in Molecular Biology), both Frances H. Arnold, George Georgiou (publisher), Springer, Berlin
“Protein Engineering Protocols” (Methods in Molecular Biology), Katja M. Arndt and Kristian M. Muller (publisher), Springer, Berlin.

**Responsible for Module:**
Sieber, Volker; 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

## CS0019: Chemistry of Enzymes | Chemistry of Enzymes [COE]

Version of module description: Gültig ab winterterm 2022/23

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

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

**Description of Examination Method:**
To proof whether the students are able to understand and to describe more complex enzymatic reaction mechanisms and deduce starting points for new enzymes from that, an oral examination takes place with a duration of 30 minutes.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
The lecture first gives an insight into the kinetic processes of enzymatic reactions and their descriptions. Then the katalytic mechanisms from a chemical point of view are presented and analyzed by means of enzymes of all six enzyme classes (e.g. acid/base catalysis in hydrolases, one-electron reactions, oxygenation, radical catalysis etc), whereby here more complex mechanisms are illuminated. The different coenzymes are introduced and their interaction with the substrates and the protein backbone is explained. For selected enzymes the mechanisms are presented in relation to the applications.

**Intended Learning Outcomes:**
After participating in the module sessions, students will be able to understand which complex catalytic mechanisms proceed in enzymes and how they are analyzed. This enables them to assess which chemical reactions are enzymatically possible and which non-natural modifications are necessary to establish new reactions. Thus, the students can for example open up the function of newly found enzymes and develop new enzymes

**Teaching and Learning Methods:**
The lecture will be performed as ex-cathedra teaching to familiarize the students with all necessary basics. The lecture is interrupted by short exercises/question-answer units to stimulate independent, critical thinking. In the seminar, the students will acquire the mechanisms for selected enzyme systems in self-research, introduce them to their fellow students and solve in a group work concrete problems of varying complexity.

**Media:**
PowerPoint, script, task sheets

**Reading List:**

**Responsible for Module:**
Dr.-Ing. Ammar Al-Shameri

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

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

## Module Description

### CS0032: Seminar on Optimization Methods and their Application | Seminar on Optimization Methods and their Application [SemOMA]

Version of module description: Gültig ab summerterm 2023

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The examination consists of a written seminar paper as well as an oral presentation & discussion. The seminar paper should cover 15–20 pages and be written in the style of current publications of peer-reviewed journal articles. In addition to the seminar paper, optimization models and methods may have to be implemented in order to conduct numerical analyses, which will be handed in as a digital appendix. At the end of the module, students present their work in a 45 minutes presentation. Both parts (the written paper and the presentation) are weighted equally to the final grading.

**Repeat Examination:**

**(Recommended) Prerequisites:**
The module covers optimization models and methods and their application in operations research. To study these models and methods, methodological knowledge on optimization methods as obtained, e.g., in the module CS0098 (Operations Research) is required.

**Content:**
The seminar focuses on recent research developments on varying topics related to optimization methods and their application in operations research. Students learn to model practical problems arising in different areas of operations research as optimization problems and to solve the resulting problems using suitable methods. Thereby, mathematical optimization models and methods from areas such as (mixed-integer) linear programming and network optimization (e.g., shortest path or network flow problems) are used to solve relevant practical problems.

**Intended Learning Outcomes:**
The objective of the module is to equip the participants with the necessary skills for writing academic papers and tools for a successful master’s thesis project.

Specifically, the aim is to be able to:
- Read and understand recent research contributions
- Pursue interesting and relevant research questions
- Conduct a literature study and/or numerical study and/or implementation concerning a specific topic
- Structure and organize research methods and results
- Write a seminar paper
- Present research findings and defend them in an academic discussion

**Teaching and Learning Methods:**
In an introductory session, the current theme of the module is explained by the lecturer and the various available seminar topics are elaborated in detail. Moreover, information on relevant literature for the problem settings is introduced, which forms the basis of the students' seminar papers. After the introductory session, students will work out their assigned topics independently own or in small groups by using their abilities of conducting literature research, mathematical modelling, programming, and quantitative analyses. Throughout the project, they receive guidance from a supervisor. Different milestones such as a preliminary outline of the seminar paper, first research results, and the final paper are to be achieved. Following the submission of the final paper, presentations and discussions of all students' seminar papers are conducted, where also presentation, moderation, and discussion skills are trained.

**Media:**
Research paper; presentation slides

**Reading List:**
F. Petropoulos et al. - Operational Research: Methods and Applications, Journal of the Operational Research Society, Volume 75, Issue 3, pp. 423-617 (2024)
M. Carter, C. C. Price, G. Rabadi - Operations Research: A Practical Introduction (2nd ed.), Chapman and Hall/CRC (2018)

**Responsible for Module:**
Thielen, Clemens; 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

## CS0104: Biogenic Polymers | Biogenic Polymers [Bioplar]

Version of module description: Gültig ab winterterm 2020/21

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
During the seminar, students independently work on a topic from the field of biogenic polymers, and give an oral presentation. Group work is optional. Assessment requires an oral examination (30 minutes). Students demonstrate their knowledge of physico-chemical properties of biogenic polymers as well as possible applications. Students are able to develop options for chemical synthesis and analysis of physico-chemical properties of bioplastics. No further tools are allowed in the examination.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Successful participation in "Basics in Chemistry" and knowledge of materials and chemical compounds, or comparable knowledge on chemistry and physics.

**Content:**
The module deals with structure and function of natural bio-macromolecules (in particular polysaccharids and proteins). Furthermore, basics of biogenic polymers will bei discussed in the view of polymers holding potential for applications in future technology. The topic of chemical synthesis and derivatization of bioplastics for use in industry is introduced (e.g. cellulose derivatives). Special focus is set on the development of options for chemical synthesis and its competent application. Physico-chemical properties of bioplastics as well as their characterization is central to the lecture.
The seminar takes the form of a journal club with students independently work on reserach papers and their presentation to fellow students.

**Intended Learning Outcomes:**
After participation, students are able to classify different kinds of bioplastics with respect to their possible application. They are competent to evaluate the production processes of biopolymers used in technology and can classify them according to their profile of properties. The module enables students to decide on appropriate synthesis methods to meet specific requirements in the industry. Students will also be able to use physico-chemical analysis methods in a competent way.

**Teaching and Learning Methods:**
Lecture (talks given by teaching staff using PowerPoint media, books and additional written document), seminar (independent work on a topic including a presentation, peer instruction and constructive criticism)

**Media:**
Presentations, slide notes

**Reading List:**
Endres, H.J., Seibert-Raths, A., Technische Biopolymere, Carl Hanser Verlag, München, 2009

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Biogenic Polymers (Seminar) (Seminar, 1 SWS)
Zollfrank C [L], Helberg J

Biogenic Polymers (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Zollfrank C
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0143: Hydropower | Wasserkraft [HyPo]

Version of module description: Gültig ab winterterm 2023/24

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>German | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The basics of energy generation from hydropower are assessed in a written examination (60 minutes).

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basics in Mathematics and Physics
Basics in Energy Technology

**Content:**
"In-depth knowledge regarding energy generation from water power is taught in this module. The technologies used for this purpose will be presented from the following points of view:
• Physical basics
• construction types and system components
• Planning, erection and operation
• Power output and energy supply
In addition to technical features of plants, their effects on the environment as well as sustainability considerations are covered. Legal framework conditions as well as the economic aspects of using water power are discussed as well. "

**Intended Learning Outcomes:**
After completion of the module, students are able to characterize various types of plants for the use of hydropower. They can recognize and understand the plants from the point of view of energy and technology.

**Teaching and Learning Methods:**
The module consists of a lectures with integrated excercises. Lectures include talks and presentations as well as exercises. Students should be encouraged to study the literature and discuss about the topics. In addition, practical excercises with measurement equipment and an excursion may be included.

**Media:**
PowerPoint
Blackboard

**Reading List:**
Jürgen Giesecke, Emil Mosonyi: Wasserkraftanlagen. Springer, 2009. ISBN 978-3-540-88988-5

**Responsible for Module:**
Prof. Josef Kainz

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

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

# Module Description

## CS0147: Energy Efficient Buildings | Energy Efficient Buildings [EEB]

Version of module description: Gültig ab winterterm 2022/23

| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
|---|---|---|---|
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Students demonstrate their knowledge and understanding of the differenct aspects of energy efficient buildings in form of a written examination (90 minutes). Students deliver definitions, describe and outline relevant processes, mechanisms and requirements of energy efficient buildings. Furthermore, students calculate different technical specifications and parameters based on provided practice-oriented examples.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basics of physics, Basics of energy technology

**Content:**
The course focuses on the variety of options for implementation and/or enhancement of energy efficiency in new and existing buildings. This includes an introduction to relevant expert knowledge of energy and ressource efficient building materials and construction. In addition, typical measures for the enhancement of energy efficiency in existing buildings will be presented and evaluated concerning ther sustainability. The second part of the module is concerned with renerwable energy based systems for heat and warm water provision of buildings. Specific advantages and disadvantages of the presented technologies will be discussed in regards to building and usage type. In addition to the presentation of individual measures, it will be analyzed how concepts for energy efficient buildings can be include in modern building infrastructure and on living quarter scale.

**Intended Learning Outcomes:**
"After successful completion of the module, students acquire in-depth understanding of  factors determining the energy efficiency of buildings and relevant legal requirements. Students can

evaluate the sustainability of actions to enhance the energy efficiency of (existing) buildings. In addition, students can understand as well as evaluate and explain advantages and disadvantages of systems for heat and warm water provision based on renewable energies in regards to building and usage type.

Students prepare short, practice-oriented tasks as homework in a project team (group work). Thereby, they acquire the ability to view and assess information within a limited period of time and solve practice-oriented questions. The edited information and results are passed on to the other participants accordingly with the focus on sharing results in the form of a written report as well as team work.

**Teaching and Learning Methods:**
The content is taught in lecturs and presentations. In addition, case studies and exercises will bei discussed. Students should bei encouraged to individual literature study and discussions on the theme.

**Media:**
PowerPoint, blackboard, videos

**Reading List:**
Bauer, M., Mösle, P., Schwarz, M. (201.): Green Building: Leitfaden für nachhaltiges Bauen. Springer Vieweg. Daten von Fachagenturen: BINE Informationsdienst, vom Bundesumweltministerium bzw. entsprechenden Landesministerien und anderen internationalen Organisationen.

**Responsible for Module:**
Vienken, Thomas; 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

## CS0149: Renewable Resources in Medicine | Renewable Resources in Medicine

Version of module description: Gültig ab summerterm 2023

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

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

**Description of Examination Method:**
The Assessment consists of a written examination (90 minutes)

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Requirements for the successful participation is basic knowledge in chemistry, cell and microbiology, biochemistry, materials science and renewable ressources

**Content:**
The course provides basic knowledge on the human anatomy, cell biology on general and the cell membranes in particular. The interaction of materials with cell surfaces and tissue will be introduced. The general issues related to pharmacology and the fabrication of drugs from from renewable ressources will be discussed.  The application of renwable resources as the main course topic in surgery, internal medicine, plastic and reconstructive surgery as well as wound dressings will introduced. Future tasks for the medical application of renewable resources are outlined. The legislative framework for application of medical products and fabrication will be discussed.

**Intended Learning Outcomes:**
The successful visit of this course enables the students to select materials from renewable ressources for relevant fields in medicine (skin, muscle, bone) and can particularly assess the valueof their applicability. They are able to apply the most important legislation in medical application and to validate the material reqeuiements  for the application in humans (biocompatibility). They are able to identify and develop new concepts for sustainable materials

from renwable ressources in medicine due to their aquired medical, chemical and materials science knowledge and they can set the base for the potiental application of such materials.

**Teaching and Learning Methods:**
Lecture (talk by teaching staff) with media, seminar on case studies

**Media:**
Presentation, script, examples, case studies

**Reading List:**
The following literature is recommended: Buddy Ratner et al.: Biomaterials Science - An Introduction to Materials in Medicine, Elsevier

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

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

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

# Module Description

## CS0156: Material Application for Renewable Resources | Material Application for Renewable Resources

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
During the seminar, students independently work on a selected topic from the field of biobased materials and give an oral presentation with PowerPoint-handout (min. 10 slides). Group work is compulsory (3 – 5 persons). The students will implement their own online survey and present the findings in the context of the relevant literature in the presentation (each student has to present 5 minutes). The oral presentation shall be assessed according to content of the PowerPoint-handout and rhetoric aspects. The PowerPoint-handout summarizes the relevant literature, data, and key findings. Weighting: PowerPoint-handout 1, oral presentation 1.
The seminar work is not part of the written exam. However, midterm bonus points can be achieved which will have an effect on the individual final grade (-0,3).

Assessment requires a written examination (90 minutes). Students demonstrate their knowledge of physico-chemical properties and possible applications of biobased materials, as well as their environmental impact. Students are able to develop options for chemical synthesis and production processes of biobased plastics. No further tools are allowed in the examination.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Successful participation in  "Basics in chemistry " and “Biogenic Polymers”, as well as knowledge of materials and chemical compounds, or comparable knowledge of chemistry and physics.

**Content:**
Lectures give an overview the applications for biogenic resources in materials industry. Starting with the chemical composition and physic-chemical properties of the raw materials, the module introduces students to production and processing of biodegradable and non-biodegradable

bioplastics, as well as of natural fibre composites. It also covers material properties, relevant fields of application, their environmental impact, as well as current market trends.
In the seminar, students independently work on research papers and based on that, give a presentation to fellow students.

**Intended Learning Outcomes:**
After successful participation, students are able to assess opportunities and barriers for the application of biobased plastics, as well as their environmental impact compared to conventional plastics. Above all, they are competent to select suitable feedstocks, classes and types of materials, as well as processes to meet the technical requirements of a specific target product, having lower environmental impact at the same time.

**Teaching and Learning Methods:**
Lecture (talks using PowerPoint slide media, books and additional written material), seminar (independent work on a selected topic with subsequent presentation, peer instruction and constructive feedback).

**Media:**
Presentations, slide notes

**Reading List:**
Endres, H.J., Seibert-Raths, A., Technische Biopolymere, Carl Hanser Verlag, München, 2009
Pickering, K. L. (Hrsg.): Properties and performance of natural-fibre composites, CRC Press, Boca Raton 2008
Lewin, M.(Hrsg.): Handbook of Fibre Chemistry, Marcel Dekker, New York, 1998

**Responsible for Module:**
Fink, Bettina; 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

# CS0164: Basics of Numerical Methods and Simulation | Basics of Numerical Methods and Simulation [NumS]

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Examination shall be done in the form of a written test. As an aid the materials (lecture slides, example programs) used during the lecture may be employed. The students show by solving programming tasks that they know the basics of Matlab and are able to employ it to implement simple numerical methods. They apply these methods to specific technical problems in case studies. In doing so, they also demonstrate their capability to discern which way to solve a problem is appropriate.
Exam duration: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
WZ1600 Physics, CS0 Mathematics

**Content:**
- Basics of programming using Matlab/Simulink
- simple numerical methods: Systems of linear equations, numerical integration & differentiation, finding zeros,
- numerical solution of differential equations
- application of methods by using case studies (e.g. mechanical and electric systems)
- basics of optimization

**Intended Learning Outcomes:**
After having participated in the module units the students understand basic concepts of various numerical methods. They can apply these methods to case studies presented in the course methods using self-created programs in Matlab/Simulink. In doing so, they have also learned

to implement different solutions and discern how appropriate to the problem they are. In simple cases, they are also able to evaluate their results in terms of plausibility and accuracy.

**Teaching and Learning Methods:**
The module consists of one lecture and an associated session of exercises. Contents of the lecture shall be imparted in a speech and deepened through independent preparation of exercises by the students. Processing of exercises is often done by independent preparation of programming tasks.

**Media:**
Presentations,  writing on the board, demonstration of programmes/scripts

**Reading List:**

**Responsible for Module:**
Kainz, Josef; 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

# CS0255: Current Topics in Machine Learning and Bioinformatics | Current Topics in Machine Learning and Bioinformatics [CTMLBI]

Version of module description: Gültig ab summerterm 2023

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

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

**Description of Examination Method:**
The learning outcomes are tested by a graded seminar presentation with a duration of approximately 45 minutes including a discussion with the audience. The seminar allows the students to assess the extent to which they can summarize a complex scientific work in the field of Machine Learning or Bioinformatics correctly and present it to an audience in a comprehensible and convincing way. Furthermore, to assess the skill to quickly understand, review and critically discuss recent research in these fields, the active participation and discussions of the other seminar presentations will be considered as well.

**Repeat Examination:**

**(Recommended) Prerequisites:**
Knowledge in Machine Learning and Bioinformatics (e.g. Bioinformatics (WZ1631) and Artificial Intelligence for Biotechnology (CS0012)) is expected

**Content:**
At the beginning of this course, introductory lectures about current topics in Machine Learning and Bioinformatics will be given. The following topics are treated exemplarily:
- Ensemble learners
- Neural Networks (Basic concept, Feedforward neural networks, Recurrent Neural Networks, Convolutional Neural Networks, Generative Models)
- Green Artificial Intelligence
- Genome-wide Association Studies
- Phenotype Prediction
- Protein-Protein Interaction Network Analysis
- Protein Prediction

- Data Driven Biotechnology
In this course, we will also talk about recent Machine Learning and Bioinformatics research and how it can support sustainability, e.g., by guiding downstream research with data-driven approaches. Furthermore, we will also look at Green Artificial Intelligence, a research direction that aims to make resource-intense AI development more sustainable. After introductory lectures, each student will analyze a recent scientific paper in these research areas in self-study and present it to the course. Active participation and discussions in all the other presentations is expected.

**Intended Learning Outcomes:**
After successful participation in this module, students will be able to understand and present recent research in Machine Learning or Bioinformatics. They are enabled to analyze recent scientific publications in one of the two fields. Based on this knowledge, they can summarize and present a scientific paper in a concise and understandable way as well as to discuss recent research in Machine Learning or Bioinformatics. Furthermore, students know about current research directions in these scientific fields and know how current Machine Learning and Bioinformatics research supports sustainability.

**Teaching and Learning Methods:**
At the beginning of this course, introductory lectures to current Machine Learning and Bioinformatics topics will provide additional and necessary fundamentals to understand recent scientific publications. Furthermore, each student will analyze a recent research paper in one of the two fields in self-study and present it to the course to train the ability to understand advanced concepts. Beyond that, for further training of these skills, the paper presentations will be discussed in the course.

**Media:**
Slide presentation, blackboard, discussion forums in e-learning platforms

**Reading List:**
Pattern Recognition and Machine Learning, Christopher M. Bishop
Deep Learning, Ian Goodfellow, Yoshua Bengio, Aaron Courville

**Responsible for Module:**
Prof. Dr. Dominik Grimm, Florian Haselbeck

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

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

# Module Description

## CS0260: Energy and Economics | Energy and Economics [EUW]

Version of module description: Gültig ab summerterm 2022

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

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

**Description of Examination Method:**
The examination will take the form of a written test (60 minutes). The students prove that they can understand and answer questions and the connections between the energy conversion, the conversion of renewable raw materials, the energy supply in general and the current energy-political and economic situation. Group work can be included and be part of the exam.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Prior participation and passing of the fundamentals of Thermodynamics module is required for participation in the Energy and Economics module.

**Content:**
The module deals with the basics of energy sources, climate change and the technology of the heat, electricity and fuel market and the use of renewable raw materials, including an introduction to simple technical systems and current topics on the energy industry. It also deals with electricity trading, CO2 trading and the current situation of various energy technologies.
In exercises small examples are calculated to the economy (production costs of heat and power of plants (e.g. combined heat and power plants).

**Intended Learning Outcomes:**
By participating in the module, students will be able to understand the energy sources and simple principles of energy conversion into heat and electricity. They can perform simple economic assessments of energy systems and understand related market mechanisms of the electricity and heat market.

**Teaching and Learning Methods:**
The module consists of a lecture with exercises. The contents of the lecture are conveyed in the lecture and through presentations.

**Media:**
Presentations, exercise

**Reading List:**
Kaltschmitt, M.; Hartmann, H.; Hofbauer, H.: Energie aus Biomasse, 2. Auflage, Springer, ISBN 978-3-540-85094-6, 2009
Karl, J.: Dezentrale Energiesysteme, Oldenbourg, ISBN 3-486-27505-4, 2004/

**Responsible for Module:**
Gaderer, Matthias; 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

## CS0261: Phytopharmaceuticals and Natural Products | Phytopharmaceuticals and Natural Products [Phytopharm]

Version of module description: Gültig ab summerterm 2022

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
Knowledge of the covered topics of phytopharmaceuticals and natural products compounds is assessed in a written examination (90 minutes). In addition, students are required to explain the medicinal effects of medicinal plants in the examination using examples.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Organic and anorganic chemistry, botany

**Content:**
Content of the lecture:
-definition of medicinal plants and phytopharmaceuticals
-position of phytopharmaceuticals in pharmacology
-compounding (tea drugs, soluble extracts, sCO2 extracts, steam destillation, pure substances)
-effect-determining components and frequent mechanisms (inflammation cascade, infections, coagulation system, neurotransmission, digestive system)
-typical medicinal plants grown in Europe
-international trade in medicinal plants
-important classes of compounds (terpenes, steroids, coumarine, alcaloids, vitamins, saccharides)
-quality determination and typical methods (chromatography)
-falsification and chemotype (chemical race)
-drug regulator affairs (authorisation, documents)
-use of medicinal plants in practice

**Intended Learning Outcomes:**
After their participation, students can explain the production of phytopharmaceuticals derived from typical medicinal plants (from collection to quality control). They can relate chemical compounds and medical effects of typical examples.

**Teaching and Learning Methods:**
The lecture takes the form of oral presentation given by teaching staff with the help of PowerPoint media, books and other written material.

**Media:**
PowerPoint presentation and printed handout. Laboratory equipment for experiments.

**Reading List:**
Deutschmann, F., Hohmann, B., Sprecher, E., Stahl, E., Pharmazeutische Biologie, 3 Bde., G. Fischer Verlag, 1992

**Responsible for Module:**
Riepl, Herbert; 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

## CS0263: Geothermal Energy Systems | Geothermal Energy Systems [GeoE]

*Potentials of geothermal energy supply*

Version of module description: Gültig ab winterterm 2022/23

| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
|---|---|---|---|
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Students demonstrate their knowledge and understanding of geothermal systems and their potential for energy supply in form of a written examination (90 minutes). Students deliver definitions, describe and outline relevant processes for the geothermal energy supply. Furthermore, students calculate different technical specifications and parameters based on provided practice-oriented examples.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Successful completion of the module "Basics in engineering" and "Introduction to Energy conversion and Energy economy". Knowledge and interest in Geology and Physics are valuable.

**Content:**
The course focuses on the variety of options for geothermal energy supply. This includes an introduction to relevant geological expert knowledge such as formation of the earth, earth's structure, geothermal heat sources, the rock-cycle as well as mechanism of subsurface heat transport. After an introduction to deep geothermal exploration (drilling, drilling technology and related risks) the focus of the course is placed on shallow geothermal energy and use of ground-coupled heat pump systems.

This includes the design and working principle of a heat pump system and its integration in technical building equipment as well as the analysis of their ecological and economic sustainable operation on living quarter scale. The analysis is also done with regards to existing technical guidelines as well as legal boundary conditions. Practice-oriented tasks will be used to

demonstrate and critically evaluate the basic planning steps of heat pump systems and obtaining the relevant parameters. Existing and innovative geothermal exploration concepts will be analyzed and discussed against this background.

**Intended Learning Outcomes:**
After successful completion of the module, students acquire in-depth understanding of geothermal energy systems including relevant geological and hydrogeological processes. Students can evaluate the ecological as well as economic sustainability of geothermal heat source systems. They can test plausibility of dimensioning ground-coupled heat pump systems and understand, explain and comprehend heat transport processes and regeneration processes within the subsurface.

Students prepare short, practice-oriented tasks as homework in a project team (group work). Thereby, they acquire the ability to view and assess information within a limited period of time and solve practice-oriented questions. The edited information and results are passed on to the other participants accordingly with the focus on sharing results in the form of a written report as well as team work.

**Teaching and Learning Methods:**
The content is taught in lectures and presentations and strengthened by case studies and exercises. If applicable, the module is complemented by an excursion.

**Media:**
Lecture, Power Point presentation, blackboard, case examples, topics prepared and presented by participants.

**Reading List:**
Bayerisches Staatsministerium für Landesentwicklung und Umweltfragen (2005): Oberflächennahe Geothermie.
Bauer, M., Freeden, W., Jacobi, H., Neu, Th. (Hrsg.) (2018): Handbuch Oberflächennahe Geothermie. Springer Spektrum, 1. Auflage.
Stober, I. & Bucher, K. (2014): Geothermal Energy. Springer Spektrum, 1st edition.
Hölting, B., Coldewey, W.G. (2013): Hydrogeologie. Springer Spektrum, 8. überarbeitete Auflage.
Dassargues, A. (2018): Hydrogeology: Groundwater Science and Engineering, CRC Press, 1st edition.
Grotzinger, T. & Jordan, T. (2017): Press/Siever Allgemeine Geologie. Springer Spektrum, 7. Auflage
Grotzinger, T. & Jordan, T. (2014): Understanding Earth. W.H. Freeman & Company, 7th edition

**Responsible for Module:**
Vienken, Thomas; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Geothermal Energy Systems (Vorlesung mit integrierten Übungen, 4 SWS)

Vienken T [L], Vienken T
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0264: Polymer Processing | Polymer Processing [PolyProc]

*Processing of polymers intro plastic parts*

Version of module description: Gültig ab summerterm 2024

| **Module Level:** Master | **Language:** English | **Duration:** one semester | **Frequency:** winter 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:**
The content and learning objectives of the lecture are examined at the end of the semester in a written test (90 min). An oral pre-test containing safety relevant laboratory work issues must be carried out before the individual pratical course. A written report on the practical course consisting of approximately five pages must be submitted. The written report is an ungraded student achievement.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Polymer chemistry, polymer physics, rheology fluid mechanics, Biogenic Polymers

**Content:**
The lecture deals with unit operations, basic techniques and processes of plastic material processing, e.g. compounding, extrusion, injection molding, plastic part forming processes and also typical applications. In addition, methods for characterizing thermal and mechanical properties are presented. One focus here is the connection between the processing parameters and the end-use properties. The acquired knowledge is deepened in the accompanying practical course. Injection molding and extrusion tests are carried out and the test specimens are then characterized with regard to their thermal, optical and mechanical properties. Additional foci will be laid on the chemistry, structure and classification of polymers and plastic parts. The lecture also deals with the physical properties of polymers and plastic materials involving materials science. Characterization of the mechanical and thermal properties and their effects on processing, viscosity, viscoelastic behavio will be discussed

**Intended Learning Outcomes:**
In addition to the chemical-physical basics of polymeric materials, this module imparts the methodical knowledge about classic and modern innovative processing methods of polymeric materials. The students are able to sensibly classify plastic materials, their manufacture and use them for specific applications. The basics for the production technology of plastic materials are acquired. After successfully completing the module, students are able to select and use methods for processing plastic. They will be able to assess sustainability aspects of the polymer production process in terms energy consumption and materials use. Through practical work, the competence for the meaningful use of testing and characterization methods of polymer materials is acquired.

**Teaching and Learning Methods:**
Lecture (lecture by teaching staff with Power Point slide media, books and other written material), laboratory practical course (experimentation of the students under supervision)

**Media:**
Power Point slide presentations; Drawing and writing on a black board; Laboratory equipment for experimentation

**Reading List:**
Polymer Engineering; Technologien und Praxis; Peter Eyerer, Peter Elsner, Thomas Hirth
Polymer Extrusion; Chris Rauwendaal
Extrusion: The Definitive Processing Guide and Handbook; Harold F. Giles, Jr.
Einführung in die Kunsstoffverarbeitung; Michaeli, W.
Werkstoffkunde der Kunststoffe; Menges, G.

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Polymer Processing (Practical) (Praktikum, 1 SWS)
Zollfrank C [L], Helberg J

Polymer Processing (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Helberg J
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0266: Sustainable Chemistry | Sustainable Chemistry

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
The examination will take the form of a written test (60 minutes). In this examination the competence for the evaluation of chemical processes and for the derivation of optimization strategies shall be proven. No aids are permitted in the written examination. In order to additionally check whether the students are able to communicate scientific topics in front of an audience and whether they are able to critically deal with problems in individual steps, the results of the processing of the case studies are presented in the form of a 20-minute presentation alone or in a group. This presentation is ungraded study achievement.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Successful participation in the module "Basics in chemistry" or comparable knowledge in chemistry.

**Content:**
The module teaches basic principles of sustainable chemistry. Focus is set on the evaluation of chemical processes in view of efficiency, atom economy and amount of waste. In addition, optimizsation strategies related to catalytical methods, raw material and energy efficiency are discussed. Students individually prepare current topics related to sustainable chemistry and present them in the seminar.

**Intended Learning Outcomes:**
By attending the module events, students are able to highlight the principles of sustainable chemistry. Students can analyze the efficiency and waste quantities of chemical reactions and evaluate various alternative processes. Furthermore, they are able to discuss further chemical aspects of the conversion of renewable raw materials into valuable products. Through the

independent development of case studies, the students master all the steps that are important in the critical examination of problems (consideration of the example, development of criteria for evaluation, assessment, presentation of the results to an audience).

**Teaching and Learning Methods:**
Lecture with board addresses and presentations: Basic development and derivation of technical contents; seminar with written tasks. Consolidation of the technical learning contents through learning activity of the students themselves, e.g. through independent development of case studies from the field of sustainable chemistry.

**Media:**
Presentation, script, examples

**Reading List:**
Stanley E. Manahan: Green Chemistry, ISBN: 0-9749522-4-9

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Sustainable Chemistry (Seminar) (Seminar, 1 SWS)
Zollfrank C [L], Helberg J, Zollfrank C
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0267: Biological Materials | Biological Materials

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Understanding of the course contents and their application will be tested in a written exam of 90 minutes duration. In detail, the students are required to describe the physical and chemical foundations of the formation, as well as relations between the hierarchical structure and properties, of typical biological materials. Further, the transfer of this knowledge to technological applications and to the design of novel biologically inspired materials, as covered in the course, is a test subject. Lecture notes are not permitted.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge in geometry and chemistry

**Content:**
The module Biological Materials in Nature and Technology covers important biological functional materials, based on basic materials scientific knowledge. This encompasses such materials that fulfill, in their biological system, or in a technological application, either in native state, or modified, one or more specific functions. Differences and similarities to classical engineering materials are pointed out. In addition to the modules Bioinspired Materials and Instrumental Analysis, the students learn important methods for structural and property analysis. After a presentation of the classification of biological materials, students- are taught the basic correlations between hierarchical structuring and macroscopic properties. As the most important complex, the influence of hierarchical structuring on the mechanical properties of materials will be discussed. The students learn, which modes of failure can occur in biological systems and how they are influenced. In this context, modification routes for biological materials are shown and discussed.

**Intended Learning Outcomes:**
After successful completion of the module, the students are enabled to name criteria for a proper usage of biological materials. They can name specialized methods for the analysis of hierarchical structures and the derived material properties and explain the correlations between structure and external properties. Further, they are able to describe tailored modification routes for biological materials.

**Teaching and Learning Methods:**
Lecture with discussion and case studies

**Media:**
Presentation, slides

**Reading List:**
Structural Biological Materials: Design and Structure-Property Relationships. Eds Elices M, Pergamon-Elsevier Science Ltd, Oxford, (2000).
Fratzl P & Harrington MJ. Introduction to Biological Materials Science. Wiley VCH, Weinheim, Germany, (2015).

**Responsible for Module:**
Van Opdenbosch, Daniel; 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

## CS0305: Research Excursion Master | Research Excursion Master

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>irregularly |
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>60 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
Passed/not passed:
The module is passed when the students deliver a learning portfolio consisting of the following elements::
1. 2 written pages or 20’ presentation on preparatory work for the excursion. The form and the due date will be specified in the kick-off session.
2. At least two topical contributions to the excursion (topical input, interviews, questions on presentations and during site visits, discussion contributions;
3. 5-10 PPT slides reflecting the findings based on a case study visited during the excursion. The due date will be specified in the kick-off session;
4. Final report of case studies and results of the workshop;

All four elements of the learning portfolio have to be delivered to pass the module.

**Repeat Examination:**

**(Recommended) Prerequisites:**
Prerequisites may be defined by the professors / lecturers offering the excursion, dependent on the chosen destination / topic. They will be announced with the announcement of the excursion 1 month before the start of lectures in the semester in which the excursion is offered, at the latest.

**Content:**
The research excursion deals with individual topics from modules and / or the study programs for which it is designed. On an individual basis, professors and lecturerers from these modules / study programs offer the research excursion to a topic or place of their choice.

A bullet point list with typically 10-12 entries will be provided by the professors and lecturers with the announcement of the research excursion 1 month before the start of lectures in the semester in which the excursion is offered, at the latest.

After the excursion the results of the applied methodologies are presented and discussed in a workshop. Key findings and the results of the workshop are included in a final excursion report by the students.

**Intended Learning Outcomes:**
The excursion aims to support the scientific profile building of students and the acquisition of scientific, practical and social competencies and the application to case studies visited during the excursion. It supports the competence acquisition in other modules and / or the study programs in general. The students get practical insights into the topical field of the research excursion, deepen their comptencies in this field regarding ongoing research and apply their competencies to real case studies in practice.

In particular, the intended learning outcomes are the following:
- Select relevant scientific and practical information and recall it for for visits of organizations, cities and talks with experts and stakeholders,
- Prepare questions regarding the state-of-knowledge, open research questions and practical relevance and discuss these with fellow students,
- Discuss research and practical knowledge with stakeholders,
- Recognize the implementation of research and practical knowledge in the organisations / sites visited,
- Reflect on the state of implementation of theoretical knowledge in practice,
- Discuss with fellow students and supervisors gained insights and compare it with their expectations,
- Perform structured interviews and talks with experts and stakeholders in practice
- Apply methodologies from theoretical lectures and exercises on practical organizations

**Teaching and Learning Methods:**
The research excursion consists typically of the following elements (teaching, learning and application of methods):
- Kick-off session: To achieve a good get-to-know, brief the students about the module contents, course and required performance an interactive in-presence workshop will be carried out. This covers presentations, and interactive elements such as role games etc.
- Individual work and feedback: In order to prepare for the on-site visits the students carry out own literature research on the excursion topics. To document their learning progress and to be able to share the results they summarize their findings in written form. A presentation of the contents in front of the fellow students is an optional element. In this process, they are supervised, receive materials and continuous feedback.
- On-site visits: 3-5 day research trip with site-visits, presentations, discussions with stakeholders, interviews of experts etc. This part will be specified in the specific program of the research

excursion and can due to the variety of possible destinations and topics not be specified further at this point.
- Individual work: the students will reflect their learnings in written form,
- Workshop: the students will present and discuss their findings in a workshop to gain practical experience for their future working conditions and formulate a final excursion report.

**Media:**
Digital projector, board, flipchart, online contents, recent scientific journal publications, equipment and utilities demonstrating production processes in practice

**Reading List:**
Topic related reading, especially articles in international peer reviewed journals, will be provided during the course of the module.

**Responsible for Module:**
Prof. Cordt Zollfrank Prof. Hubert Röder Prof. Magnus Fröhling

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

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

## Module Description

### SOT86701: EuroTeQ Collider. Enhancing Connections for Sustainable Futures (MSc) | EuroTeQ Collider. Enhancing Connections for Sustainable Futures (MSc)

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
During this module, students must complete following tasks: producing a presentation that provides information on the project concept development and implementation, as well as a final report, charting the progress of their work/research over time. These assessments will evaluate a) the success of the project and b) the learning success of the students in oral and written form. Students will be graded based on the active participation in a group project (20%), a final presentation of project results (60%) and a final project report (20%). These examination requirements will assess the success of the project, but also examine the learning success of the students in oral and written form.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
This module is aimed at all students enrolled in a Bachelor or Master program at the TUM; it is thus designed as an interdisciplinary venue which brings together a range of scientific perspectives. No specific prior knowledge is required; however, its project-based character requires high levels of intrinsic motivation and the willingness to actively participate in a project.Please register for this course via TUM Online. If you have any questions or problems to register, please send an email to euroteq@ja.tum.de

**Content:**
"Enhancing Connections for Sustainable Futures" aims to promote an integrated approach based on three main areas: People, Nature, and Technology. In the "People" domain, the focus is on empowering and enabling communities. This involves connecting people's needs and aspirations through technology, including digital solutions, in various areas such as wellbeing,

health, culture, etc. In the "Nature" realm, the call concentrates on the conscious use of nature and the consideration of its resources. This includes examining interactions in ecosystems, safeguarding biodiversity and nature conservation, as well as utilizing renewable energies. Within the "Technology" sphere, the emphasis is on establishing efficient connections through technology, both digital and physical. This encompasses various fields such as information technology, logistics, transportation, manufacturing, communication, etc. Overall, the call aims to promote sustainable connections that enable meeting human needs, protecting the environment, and leveraging innovative technologies to achieve these goals.

The Technical University of Munich (TUM) joint forces within eight leading universities of science, technology and business to foster the European spirit in a EuroTeQ format to promote innovative engineering education across Europe. Together, we are created the first EuroTeQ Collider in 2022. Now, the journey goes into the second round. The Collider is an innovative learning format with the aim of bringing students together with vocational trainees and professionals to tackle challenges. The theme for the period 2024-2026 is “Enhancing  connections for sustainable Futures”. The goal is to connect participants with different profiles and personalities to boost creativity, innovation, shared understanding, enabling participants to imagine new approaches and design disruptive solutions.

The module is a seminar that gives students the opportunity to apply their knowledge on topics related to the theme “Enhancing connections for sustainable Futures”. Within this overarching theme, we are offering challenges on three different topic-domains, namely:

• People – e.g., empowering and enabling communities, connecting people's needs and aspirations through technology (including digital solutions) in different areas such as wellbeing, health, culture, etc.
• Nature – e.g., on the conscious use of nature, taking into account environmental resources and the relationship of organisms to the environment: interactions in the ecosystem, safeguarding biodiversity and nature conservation, use of renewable energies, etc.
• Technology – e.g., efficient connections through technology, both digital and physical, in various areas such as information technology, logistics, transportation, manufacturing, communication, etc.

Within every topic domain, interdisciplinary (and international) teams of students, vocational trainees and professional learners are formed to develop solutions towards a desirable future, test and validate tools and create prototypes of their solutions. A selection of the best projects will be presented in a major high-level event, the EuroTeQaThon.

**Intended Learning Outcomes:**
After completion, all EuroTeQ Collider participants will be able to:
- Select and apply appropriate design, engineering and business approaches and tools to create an innovative and science-based solution to a real-life challenge.
- Develop a profound interpretation of a complex, real-life problem and its context using a system-thinking approach, considering multiple perspectives.

- Develop a problem-driven, creative, and integrative design, demonstrated by a concrete prototype that balances desirability, feasibility, and viability.
- Use disciplinary knowledge and expertise in an inter-disciplinary team to develop an innovative and scientifically sound solution in a European context.
- Communicate your ideas, at different levels of elaboration, via several mediums in an international context to a diverse set of stakeholders.
- Define and regularly reflect on personal and team development.

**Teaching and Learning Methods:**
A range of teaching & learning techniques will be applied:
- (pre-recorded) videos and online presentations, with podcasts and interviews, Q&A Sessions with experts
- This module is focusing on service-learning and project-based learning
- After a set of introductory sessions which provide input on the core topics but also project management, students will work on their projects in groups. Progress will be determined through project presentations during the semester, continuous feedback from the instructors, as well as peer-to-peer feedback.
- Presentational skills will be further facilitated through the requirement to present the results
- As students and professionals will work together in a joint effort, all participants will not only improve their technical skills but also enhance their soft skills such as team spirit, flexibility to work in multicultural environments, and design thinking, which are also very important in professional life.

**Media:**

**Reading List:**

**Responsible for Module:**
Finger, Peter; Dipl.-Ing. agr. (Univ.)

**Courses (Type of course, Weekly hours per semester), Instructor:**
(SOT82701, SOT86701) EuroTeQ Collider. Enhancing Connections for Sustainable Futures (Seminar, 4 SWS)
Wester A ( Finger P, Lehmann D, Schmid H )
For further information in this module, please click campus.tum.de or here.

## Electives TUM (max. 18 ECTS) | Electives TUM (max. 18 ECTS)

## Module Description

## WZ4202: Political and Social Perspectives of Renewable Resources | Political and Social Perspectives of Renewable Resources

Version of module description: Gültig ab winterterm 2015/16

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
Oral presentation of the group project work, review paper for a scientific journal. The learning outcomes are assessed by a group project work concerning a selected topic related to the political and social perspectives of renewable resources. Therefore students have to prepare a scientific paper for an international journal of their choice and give a short oral presentation about the work done for the paper, similar to what would be expected in a 15 minute conference presentation.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Knowledge of sustainable resources (materials and energy). Scientific writing.

**Content:**
In the lectures a number of examples of societal aspects of Sustainable Resource programs will be presented and discussed. Backgrounds are global developments such as urbanization, the rise of countries like China and India, resource availability and technological developments. Case studies deal with tropical forestry and pros and cons of tropical hardwood uses, urban planning, vernacular architecture and the use of renewable resources We take a tour around the world and look at social housing programs in Europe, Brazil and South-East Asia. Furthermore we look at successes and failures in the German/European energy policies in comparison to the United States.

**Intended Learning Outcomes:**
After this course, students should be able to:

1. Develop SR stimulation programs on country or regional level and priority analysis of renewable resource applications
2. Assess priorities for development and application of renewable resources in countries with different levels of development
3. Critically analyze existing SR programs taking into account social values of stakeholders,
4. Assess impacts of global developments such as urbanization and UN-policies on SR.

**Teaching and Learning Methods:**
Discussion and creativity sessions. Project work evolving in a scientific paper for a journal of choice. Oral presentation.

**Media:**
Lectures, UN-policy notes, Discussion and Creativity sessions.

**Reading List:**
Tba

**Responsible for Module:**
van de Kuilen, Jan Willem; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Political and Social Perspectives of Renewable Resources (Vorlesung, 4 SWS)
van de Kuilen J [L], van de Kuilen J, Khaloian Sarnaghi A
For further information in this module, please click campus.tum.de or here.

# Module Description

## BV460017: Hydro Power und Energy Storage | Wasserkraft und Energiespeicherung

Version of module description: Gültig ab winterterm 2022/23

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>60 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
The module examination is a written exam (60 minutes, open book, allowed tools: notes, print medias (books, printed slides…), non-programmable calculator; not allowed tools: technical devices, communication). It consists of theoretical questions and practical calculations, each about 50%.

Furthermore, they prove that they can design a water power station in concept and dimensioning as well as the state-of-the-art technologies for energy storage.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Bachelor's level knowledge in hydraulic engineering, e.g.
• "Basic Module Hydraulic and Water Resources Engineering"
• "Supplementary Module Hydraulic and Water Resources Engineering"

**Content:**
The module provides in-depth knowledge of principles, methods and technologies for calculation and management of sustainable generation of energy from hydropower.

• types of hydro power stations, specific requirements of large and small hydro power
• elements of hydro power installations
• hydro turbines: turbine types, application ranges
• stream turbines: fundamentals, turbine types, application range
• energy conversion in hydro turbines - physical fundamentals

• planning of hydro power stations: hydrological surveys, layout, power plan
• needs and requirements for energy storage
• fundamental options for power storage
• properties of storage technologies, pros and cons, application ranges, potential, development state, project examples
• pumped storage plants: fundamentals, electromechanical equipment, new approaches

**Intended Learning Outcomes:**
After successful participation in the module, students will be able
• to describe, identify and assess established and newly proposed technologies of hydropower and energy storage
• to explain and assess the physical foundations of the energy conversion as well as the fundamental approach in planning hydropower projects
• to evaluate hydropower project plans and to perform planning themselves.

**Teaching and Learning Methods:**
• lecture style
• practical examples
• coordinated moodle tests (voluntary)

**Media:**
• PowerPoint presentations with film sequences and computer animations
• blackboard exercises
• moodle tests (voluntary)
• lecture notes in moodle

**Reading List:**
See lecture notes

**Responsible for Module:**
Prof. Dr. Nils Rüther (nils.ruether@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**
Hydro Power and Energy Storage (Vorlesung, 2 SWS)
Rüther N
For further information in this module, please click campus.tum.de or here.

# Module Description

## ED150010: Sustainable Mobile Drivetrains | Nachhaltige Mobile Antriebssysteme

Version of module description: Gültig ab winterterm 2022/23

| **Module Level:** Bachelor/Master | **Language:** German | **Duration:** one semester | **Frequency:** winter 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 Modulprüfung erfolgt in Form einer schriftlichen Klausur (Prüfungsdauer: 90 min). Die Studierenden sollen in begrenzter Zeit die Konzepte nachhaltiger mobiler Antriebssysteme auf verschiedene Frage- und Problemstellungen anwenden. Damit soll z. B. überprüft werden, ob die Studierenden bewerten können, wie eine konkrete Ausgestaltung eines Antriebssystems in verschiedensten Fortbewegungsmitteln ausgeführt werden kann oder ob die Studierenden die Grundlagen der Funktionsweise und des Aufbaus von Kolbenmotoren, elektrischen Antriebssträngen und von Antriebssträngen mit Brennstoffzelle verstehen.
Als Hilfsmittel zugelassen sind: Schreibutensilien, Lineal und ein nicht programmierbarer Taschenrechner.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
None

**Content:**
Themenschwerpunkte:
* Nachhaltigkeit und Klimaschutz
* Gestaltung nachhaltiger Mobilität
* Grundlagen der Fahrzeugtechnik
* Grundlagen der Fahrzeugantriebe
* Verbrennungsmotoren mit nachhaltigen Kraftstoffen
* Elektrische Antriebssysteme (Batterie, Inverter, e-Motor)
* Antriebssysteme mit Brennstoffzellen
* Energie und Mobilität

**Intended Learning Outcomes:**
Nach erfolgreicher Teilnahme am Modul "Nachhaltige Mobile Antriebssysteme" sind die Studierenden in der Lage...
... zu verstehen, wie und warum der Klimawandel eine Transformation hin zu nachhaltiger Mobilität erfordert
... einzuordnen, wie sich diese Transformation auf die traditionellen Verkehrsmittel und ihre Antriebe auswirken wird
... zu bewerten, wie eine konkrete Ausgestaltung eines Antriebssystems in verschiedensten Fortbewegungsmitteln ausgeführt werden kann
... die wichtigsten mobilen Antriebssysteme nach ihren jeweiligen Vorteilen, Nachteilen und Einsatzgebieten zu beurteilen
... die Grundlagen der Funktionsweise und des Aufbaus von Kolbenmotoren zu verstehen
... die Grundlagen der Funktionsweise und des Aufbaus elektrischer Antriebsstränge zu verstehen
... die Grundlagen der Funktionsweise und des Aufbaus von Antriebssträngen mit Brennstoffzelle zu verstehen
... einzuordnen, welches Antriebssystem für eine gegebene Anwendung am besten geeignet ist
... zu bewerten, welchen Einfluss die Rolle des Energieträgers auf die Nachhaltigkeit des gesamten Antriebssystems ausübt
... grundlegende Zusammenhänge zwischen Energie, Mobilität und Antriebssystem kritisch zu hinterfragen
... einfache aber wirkungsvolle Grobabschätzungen der wichtigsten Eigenschaften moderner Antriebssysteme vorzunehmen

**Teaching and Learning Methods:**
In der Vorlesung werden die Grundlagen nachhaltiger mobiler Antriebssysteme anhand von Vortrag, Präsentation und Tablet-PC vermittelt. Die Theorie wird durch Anwendungsfälle erläutert und mit Hilfe von einfachen Rechenbeispielen gefestigt. Erfahrungen und Probleme aus der Praxis werden vorgestellt, diskutiert und gerechnet.
Damit sollen die Studierenden beispielsweise lernen, zu bewerten, wie eine konkrete Ausgestaltung eines Antriebssystems in verschiedensten Fortbewegungsmitteln ausgeführt werden kann sowie die Grundlagen der Funktionsweise und des Aufbaus von Kolbenmotoren, elektrischer Antriebsstränge und von Antriebssträngen mit Brennstoffzelle zu verstehen.
Alle Lehrmaterialien sowie weiterführende Informationen werden kostenfrei in der Vorlesung verteilt oder werden online zur Verfügung gestellt. Sprechstunden werden flexibel angeboten.

**Media:**
* Vortrag
* Präsentation
* Tablet-PC mit Beamer
* Online-Lehrmaterialien

**Reading List:**
Zapf, Martin: Kosteneffiziente und nachhaltige Automobile. 2. Auflage. Wiesbaden: Springer Vieweg, 2021.

Doppelbauer, Martin: Grundlagen der Elektromobilität. Wiesbaden: Springer Vieweg, 2020.
Schreiner, Klaus: Verbrennungsmotor - kurz und bündig. Wiesbaden: Springer Vieweg, 2017.
Klell, Manfred: Wasserstoff in der Fahrzeugtechnik. 4. Auflage. Wiesbaden: Springer Vieweg, 2018.

**Responsible for Module:**
Jaensch, Malte; Prof. Ph.D.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Nachhaltige Mobile Antriebssysteme [ED150010] (Vorlesung, 3 SWS)
Jaensch M [L], Jaensch M, Heindl J
For further information in this module, please click campus.tum.de or here.

# Module Description

## ED160007: Lithium-Ion Battery Production | Lithium-Ionen-Batterieproduktion [VLBP]

*Lithium-ion battery production*

Version of module description: Gültig ab winterterm 2021/22

| **Module Level:** Master | **Language:** German | **Duration:** one semester | **Frequency:** winter 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:**
The module examination takes place in the form of a written exam (examination duration 90 minutes). By means of comprehension questions, calculation tasks and transfer tasks, the students should prove that they have an understanding of the basic processes of lithium-ion battery production and that they can apply this understanding. The content of the exam consists of comprehension questions from the lecture as well as various tasks, some of which are more advanced, based on the content of the exercises accompanying the lecture. Only a non-programmable calculator is allowed as an aid.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Prior experience in electrical energy storage and production engineering is recommended. Prior knowledge in chemistry and process engineering is not required but helpful.

**Content:**
The lecture provides an insight into all process steps in the production of lithium-ion batteries. The focus is on the holistic view of the process chain, including important process parameters and influencing factors.
Detailed content:
- Structure of the lithium-ion cell, electrochemical and electro-technical fundamentals, energy storage methods
- Material and cell systems on component level, process chains of battery production, safety aspects, production environment
- Mixing processes for anodes and cathodes (stirring, mixing)

- Coating processes for anodes and cathodes (slot die, doctor blade, cascade die) and process variants
- Calendering processes (porosity analysis, defect patterns)
- Packaging and assembling (cell formats, application areas)
- Packaging and contacting (ultrasonic welding, friction stir welding, laser welding)
- Filling and wetting (electrolyte properties, electrochemical impedance spectroscopy)
- Formation and aging (passivation layer, charge/discharge rate and lifetime test)
- Electrochemical characterization, cost models, quality criteria
- Recycling (material recycling, second life of the battery cell)
- Innovative process steps (laser patterning, mechanical prelithiation) and alternative lithium-ion battery technologies (solid-state batteries, sodium-ion battery)

**Intended Learning Outcomes:**
After participating in the module, students will be able to understand basic interrelationships of lithium-ion battery production and to evaluate them.
After successful participation in the module, students will be able to:
- Demonstrate a basic understanding of the material systems processed
- Evaluate the mode of operation of a lithium-ion battery on the basis of measurement characteristics
- Know, analyze and classify all process steps in lithium-ion battery production and their variants
- Understand basic interrelationships in lithium-ion battery production
- To develop requirements for the respective processes and suitable plant technology
- Evaluate typical fault patterns and assess their possible causes and consequences for the product
- Characterize the properties of a battery cell using cell tests and correlate them with the manufacturing processes
- Know, understand and apply important methods of quality assurance
- Understand future technologies and their special features with regard to the product and be able to recognize and classify trends

**Teaching and Learning Methods:**
In the lecture, the theoretical basics of lithium-ion battery production are taught by means of lecture and presentation. With the explanations from the lecture and corresponding self-study, the students learn to understand, evaluate and develop all process steps of lithium-ion battery production. Students supplement the course material by studying the recommended literature on battery production and related areas.
Students independently solve questions and tasks related to the content of the course using practical examples. In the exercise, sample tasks are calculated, discussed and debated together with the students. This is intended to ensure that the students can independently acquire the learning outcomes and transfer performance.

**Media:**
Presentations, videos and other illustrative material are used for visualization. Via the eLearning portal, the participants receive all exercise documents for preparation, which are then discussed

in the exercises. Furthermore, the lecture materials from the lecture are made available to the participants.

**Reading List:**
Recommended basic literature:
Korthauer, Reiner (Hrsg.): Handbuch Lithium-Ionen-Batterien. Springer-Verlag Berlin Heidelberg 2013. ISBN: 978-3-642-30653-2
Gulbinska, Malgorzata K. (Hrsg.): Lithium-ion Battery Materials and Engineering. Springer-Verlag 2014. ISBN: 1447165470
Julien, Christian (Hrsg.): Lithium Batteries, Science and Technology. Springer International Publishing 2015. ISBN: 9783319191089

In addition, further literature references are recommended in the individual lectures for in-depth study.

**Responsible for Module:**
Daub, Rüdiger; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Lithium-Ionen-Batterieproduktion (Vorlesung, 2 SWS)
Daub R [L], Daub R, Jaimez Farnham E, Lindenblatt J

Lithium-Ionen-Batterieproduktion (Übung, 1 SWS)
Daub R [L], Daub R, Lindenblatt J
For further information in this module, please click campus.tum.de or here.

## Module Description

### **MW2245: Think. Make. Start. | Think. Make. Start.** [TMS]

*Build innovative products of your ideas in 10 days!*

Version of module description: Gültig ab winterterm 2024/25

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

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

**Description of Examination Method:**
The module examination consists of a project work incl. written documentation (approx. 10 pages) and presentation (10 min), in which the students develop a new product in a group project and present their idea for founding a company on this basis. The individual performance is assessed to what extent the students are able to develop a product with market potential by means of an iterative approach to prototypical implementation. The assessment also includes the ability to work in a team, the ability to make well-founded design decisions and the completeness and conclusiveness of the concept, taking into account social relevance, novelty and innovation. As part of the project work, in addition to documentation, there is a final oral presentation. Through the presentation, students are expected to show whether they can demonstrate their ability to act as a competent team.

**Repeat Examination:**

**(Recommended) Prerequisites:**
The basic requirement is a willingness to engage with new learning methods, approaches, disciplines and ways of working. Cross-role experience in project management, product development (Design Thinking, TRIZ, Systems Engineering, etc), interdisciplinary teamwork, communication skills, creativity and problem solving skills are an advantage. A lot of emphasis is placed on practical experience.

For the "Problem Expert" role, experience in the following areas is an advantage:
- User Testing, Requirements Engineering, Interviewing, Human-Centered Design, Design, Visualisation, Use Case Definition, UX/UI Design, marketing, market research, benchmarking, design thinking.

For the "Tech Developer" role, experience in the following areas is an advantage:
- Hardware (mechanical): design, manufacturing (workshop/makerspace), prototyping, CAD/CAM.
- Hardware (electronic): embedded systems engineering, microcontrollers, sensors/actuators, Arduino, Raspberry, circuitry, board design, metrology, BUS protocols, prototyping, closed-loop/ open-loop control, robotics
- Software focus: Backend development, databases, frontend development, machine learning, web development, app development, embedded systems

For the "Business Developer" role, experience in the following areas is an advantage:
- Business Plan/Strategy/Design, Marketing, Sales, Interviewing, Finance & Accounting, Business Law & Regulations, Entrepreneurship.

The number of participants is limited and there will be an application process.

**Content:**
During the interdisciplinary team project, students work methodically, purposefully and agilely on a development project to develop innovative new products with the intention of successfully launching them on the market. Current needs and problems from social, technological and economic systems are identified, analysed and validated in the interdisciplinary team. In doing so, they cooperatively solve challenges that arise from constraints from the different disciplines. They generate suitable market hypotheses and product ideas at an early stage and interact with initial potential customers/users. They iteratively create prototypes and evaluate their hypotheses with them in experiments.

For more information, visit www.thinkmakestart.com and www.tms.tum.de.

**Intended Learning Outcomes:**
After participating in the module “Think.Make.Start.” the students are able to
- reproduce the principles of user-centered design
- apply methods of product development (e.g., Design Thinking) to a challenge of their choice
- develop important hypotheses involving relevant stakeholders (customer, user, ...) through proper planning with "purposeful prototyping"
- examine the relevance of a problem and develop a solution collaboratively in an interdisciplinary team
- design a prototype based on the acquired design methods and analyzed insights
- lay the foundation for one's own business start-up by identifying a start-up idea or team.

**Teaching and Learning Methods:**
"THINK. MAKE. START." is a two-week, practice-oriented, interdisciplinary and competitive teaching format in which students from all faculties can participate (credits are given individually related to the study program). It is organised by the different chairs of TUM, TUM ForTe, and UnternehmerTUM. They get access to the high-tech workshop Makerspace and budget to transform their own ideas into real prototypes (mechatronic products). Learning outcomes are achieved through the following teaching and learning methods:

- Milestones to be achieved, team roles to be held and predetermined course structure provide the roadmap for the project.
- Coaching and teaching expertise in prototyping, business validation, agile development, design thinking, systems engineering, lean startup and user-centred design.
- Teaching the basics of interdisciplinary collaboration through a role concept (Business Developer, Tech Developer, Problem Expert).
- All participants work in interdisciplinary teams (10 teams of 5 students each) and are encouraged to become active themselves and learn through practical experience (hands-on learning).
- Each team pursues a real business idea chosen for the seminar. Special attention is given to really understanding the customer and verifying the solution approach, through questioning, observation, prototyping or expert discussion.
- Using prototyping to bridge the gap between thinking and doing.
- Reflecting on one's own results and approach supports project decisions.
- The teams present their projects to a jury on DemoDay and present the prototypically implemented product ideas to guests from industry, the start-up scene and research.

**Media:**
Project manual, presentations, hand-outs, posters, videos, examples.

**Reading List:**
Esch Franz-Rudolf (2012) Strategie und Technik der Markenführung, 7. Auflage, Vahlen

Faltin, Günter (2008): Kopf schlägt Kapital, Hanser

Halgrimsson (2012): Prototyping and Model Making for Product Design (2012)

Kalweit Andreas, Paul Christof, Peters Sascha, Wallbaum Reiner (2012) Handbuch für Technisches
Produktdesign, Material und Fertigung, Entscheidungsgrundlage für Designer und Ingenieure, 2. Auflage, Springer

Kelly, Tom (2016): The Art of Innovation

Lindemann, U (2007): Methodische Entwicklung technischer Produkte - Methoden flexibel und situationsgerecht anwenden. 2. Auflage

Münchener Business Plan Wettbewerb: Handbuch Businessplan-Erstellung, München http://www.evobis.de/coaching/handbuch/

Malek, Miroslaw / Ibach, Peter K. (2004): Entrepreneurship, Dpunkt Verlag

Moore, Geoffrey A. (2002): Crossing the Chasm, Harpercollins

Osterwalder, Alexander / Pigneur, Yves (2010): Business Model Generation: A Handbook for

Ries, Eric (2011): The Lean Startup

Savoia, Antonio (2019): The right It

Timmons, Jeffry A. / Spinelli, Stephen (2009): New Venture Creation, 7thedition, McGraw, Hill Professional

UnternehmerTUM (2011): Handbuch Schlüsselkompetenzen, 7. Auflage

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

**Courses (Type of course, Weekly hours per semester), Instructor:**
Think.Make.Start. (Praktikum, 4 SWS)
Zimmermann M [L], Tong Y, Hohnbaum K, Amm M, Büchner B, Baur C, Bien S, Mogk J
For further information in this module, please click campus.tum.de or here.

# Module Description

## WZ1590: Climate Change Economics | Climate Change Economics

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
There will be a written exam (Klausur) of 90 minutes at the end of the semester. The students will be asked to demonstrate, within the stipulated amount of time using predefined methods and resources, their ability to outline the challenges climate change poses to regulators, propose pragmatic solutions and strategies as well as ways of implementing them. This will be based on the competencies acquired from the relevant literature of economic modeling, theories of climate change, and their understanding of the course content. The written exam is an appropriate assessment method to evaluate the degree to which the students understand the theoretical framework of climate change implications as well as provides an opportunity for them to put forward arguments based on existing theory.

In addition, there is the option of taking a voluntary mid-term assignments as course work in accordance with APSO §6, 5. For this, a presentation (15 min) has to be given.
The module grade can be improved by 0.3 by passing the course work if this better characterises the student's performance level on the basis of the overall impression and the deviation has no influence on passing the examination. No repeat date is offered for the mid-term performance. When retaking a failed module examination at the next possible examination date, successfully passed mid-term assignments will be taken into account.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge:
• Micro Economics (Welfare Economics)
• Environmental Economics
• Resource Economics

**Content:**
This course covers the trends in current and future climate change and their effects on economic and social outcomes.

The lectures cover the following topics:
1. Introduction to the Basic Science of Climate Change
- The students will learn about the scientific themes of global climate change and the economic dimension of the phenomenon.
2. Basic Economics
- The students will learn how a market economy can be efficient and socially optimal as well as about the prospects of externality.
3. Optimal Emission Levels
- The students will learn of the optimal abatement path and its uncertainty with respect to damages as well as Integrated Assessment Models (IAMs).
4. Intra-generational equity in climate policy
- The students will learn about how to account for equity across space (intergenerational equity) when deriving optimal emission levels.
5. International Environmental Agreements
- The students will learn about the dynamics behind common strategies towards achieving some form of optimal emission level.
6. Policy Instruments
- The students will learn about diverse instruments such as quality-based approach and Pigouvian Tax.
7. Regulation via Prices vs. Quantities
- The students will learn what circumstances will a regulator prefer prices over quantities and vice versa.
8. Credit-based Mechanisms
- The students will learn about how to deal with countries that do not want to commit but have a high potential for low-cost reductions.
9. German Climate Policy
- The students will learn about German Climate Action - strategies and policies
10. European Union Emission Trading Scheme - EU ETS

**Intended Learning Outcomes:**
After successfully completing the module, students are able to:
• Evaluate economic models related to climate change.
• Understand theoretical models of climate change regulations as well as policies that affect emission levels.
• Comprehend the complexity, uncertainty and possibilities associated with optimal emission level.
• Analyze appropriate instruments for emission levels that are efficient and cost-effective.
• Understand different forms of climate agreements and climate action strategies that are currently being implemented

**Teaching and Learning Methods:**
The course consists of lectures (2 SWS) and seminars (2 SWS). The lecture forms the basis for the subsequent discussion within the seminar on climate change issues from an economic perspective. The content of the module is expected to be transferred to the students in an interactive learning manner (including discussions in the lectures but especially intensive discussions in the seminar) where, among others, emission reduction instruments are scrutinized. This encourages the students to independently and self-reliantly study the literature guided by a structured framework.

**Media:**
PowerPoint, flipchart, internet portals, online reports etc.

**Reading List:**
Bréchet, T., & Eyckmans, J. (2009). Coalition theory and integrated assessment Modelling: Lessons for climate governance. Global Environmental Commons: Analytical and Political Challenges in Building Governance Mechanisms.
Rohling, M., & Ohndorf, M. (2012). Prices vs. quantities with fiscal cushioning. Resource and Energy Economics, 34(2), 169-187.
MacKenzie, I. A., & Ohndorf, M. (2012). Optimal monitoring of credit-based emissions trading under asymmetric information. Journal of regulatory economics, 42(2), 180-203.
Hake, J. F., Fischer, W., Venghaus, S., & Weckenbrock, C. (2015). The German Energiewende–history and status quo. Energy, 92, 532-546.
Climate Action Plan 2050 Principles and goals of the German government's climate policy. https://www.bmu.de
/fileadmin/Daten_BMU/Pools/Broschueren/klimaschutzplan_2050_en_bf.pdf
EU ETS Handbook. https://ec.europa.eu/clima/sites/clima/files/docs/ets_handbook_en.pdf

**Responsible for Module:**
Sauer, Johannes; Prof. Dr. agr.

**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 Technology | Electives in Management and Technology

## Module Description

## CS0125: Plant and Technology Management | Plant and Technology Management [PTM]

Version of module description: Gültig ab winterterm 2020/21

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

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

**Description of Examination Method:**
Written exam (90 minutes): By solving problems from the thematic field of the module students have to prove their understanding of the management of industrial plants and technologies, their ability to techno-economic assessment and optimization methods and their analytical and verbal skills in the field. In the solution of the problems they need to demonstrate their ability to analyse technical systems, assess them from an economic point of view and apply techno-economic methods to solve planning and optimization problems arising in the life cycle of these plants.
In addition, they need to show that they are able to discuss the application of these methods in practice and to derive further research needs. Learning aids: pocket calculator.

Alternative: For smaller groups (<15 students) parts of the examination can be held in form of a case study. In this case studies, students have to demonstrate in a group work that they acquired the above mentioned abilitites by solving problems of practical relevance. This acknowledges the complexity of real world problems and the necessity to solve these in (interdisciplinary) team works. With the case study solution students have to provide a statement of the individual contributions to the solutions. Weighting: 1:1.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
-

**Content:**
The module contains units covering the following topics:
• Introduction to Plant and Technology Management
• Life cycle of industrial plants
• Analysis and modelling of industrial production systems
• Project management in engineering
• Network and facility location planning
• Investment estimation
• Cost estimation
• Plant and process optimisation
• Maintenance and repair
• Quality Management
• Re-location, dismantling and recycling

**Intended Learning Outcomes:**
The students are able to solve techno-economic analysis, planning, and optimisation problems associated with the life cycle of industrial plants. This comprises also linked topics of technology assessment and management. After completion of this module the students are able to identify and characterise these problems and structure them. Further, they are able to determine needed data and apply suitable methods for the solution of the problems. They discuss the achievements and shortcomings of these methods for a practical application. They are able to transfer these contents to an application in practice.

**Teaching and Learning Methods:**
Format: Lecture with tutorial to introduce, train and deepen the contents of the module.

Teaching / learning methods:
- Media-assisted presentations
- Group work / case studies with presentation
- Individulal assignments and presentation
The teaching and learning methods are combinded specifically for the treated topics. Typically, a thematic impulse or overview is given with a media-assisted presentation. Individual or group work assignments provide the possibility to apply the acquired competencies, to repeat and deepen these as well as to prepare the transfer to other fields.

**Media:**
Digital projector, board, flipchart, online contents, case studies

**Reading List:**
Empfohlene Fachliteratur:
1. Chauvel (2003): Manual of Process Economic Evaluation, Edition Technip
2. Couper (2003): Process engineering economics, Marcel Dekker Inc
3. Geldermann (2014): Anlagen- und Energiewirtschaft

4. Goetsch/Davis (2015): Quality Management for Organizational Excellence: Introduction to Total Quality, Pearson
5. Mobley/Higgins/Wikoff (2014): Maintenance Engineering Handbook, McGrawHill
6. Peters/Timmmerhaus/West (2003): Plant Design and Economic for Chemical Engineers, McGrawHill
Weitere Literaturempfehlungen werden in den Veranstaltungen gegeben.

**Responsible for Module:**
Magnus Fröhling

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

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

# Module Description

## CS0126: Advanced Seminar in Circular Economy and Sustainability Management | Advanced Seminar in Circular Economy and Sustainability Management [ASCESM]

Version of module description: Gültig ab winterterm 2024/25

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Term paper: Students have to write a scientific paper on the given topic (15-20 pages). In doing so they have to show that they are capable to find relevant literature, structure a problem, solve it, and document the results of the process in a scientific paper.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
-

**Content:**
"The module deals with actual topics from Circular Economy and Sustainability Management. These differ from semester to semester. Topics will be announced at the end of the preceeding semester.

**Intended Learning Outcomes:**
The seminar aims at enabling students for scientific work. After passing the module the sutdents are able to find, structure and analyse relevant literature, solve the problem scientifically, discuss the solution critically, summarize the work in a term paper, hold a scientific presentation, and discuss and defend their work. Thereby the students acquire in-depht knowledge on a current topic from the thematic field of circular economy and sustainability management.

**Teaching and Learning Methods:**
Seminar: after an introduction on the topic the students carry out a literature research, structure the problem, identify solution approaches, apply these. They summarize their findings in a term

paper and a scientific presentation. In this process they are supervised, receive materials, thematic introductions, advise in scientific work and continuous feedback in the seminar sessions. The seminar closes with a final presentation.

Teaching / learning methods:
- Kick-off session: media-assisted presentation
- Individual work and feedback
- Interim presentations / workshops
- Final presentation
- Computer lab exercises using LCA software systems and Life Cycle Inventory Data bases.

**Media:**
Digital projector, board, flipchart, online contents, recent scientific journal publications, computer lab

**Reading List:**
Recommended reading:
• Gastel B; Day R A (2017): How to write and publish a sicentific paper, Cambridge University Press
• Glasman-Deal H (2009): Science Research Writing For Non-Native Speakers Of English: A Guide for Non-Native Speakers of English, Imperial College Press
• Skern T (2011): Writing Scientific English: A Workbook, UTB

Topic related reading, especially articles in international peer reviewed journals, will be provided in the kick-off meeting of the module.

**Responsible for Module:**
Fröhling, Magnus; Prof. Dr. rer. pol.

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

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

# Module Description

## CS0123: Advanced Seminar in Behavioral Economics | Advanced Seminar in Behavioral Economics

Version of module description: Gültig ab winterterm 2024/25

| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
|---|---|---|---|
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The examination consists of a written seminar paper and an oral presentation with discussion. The seminar paper should cover 15-20 pages and is written in the style of a journal article. At the end of the module students present their work in a 30 minutes presentation. Weighting: Seminar paper 2, Presentation 1. The seminar paper demonstrates the student's ability to summarize the literature, explain research methods, present research findings and discuss them approbriately.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
-

**Content:**
This advanced seminar focuses on recent developments in Behavioral Economics. After being introduced to adequate research themes in the area of behavioral economics, students explore the academic literature on a chosen topic and develop their own research question. The topics are typically related to human behavior in an economic context and potential behavioral interventions.
Potential topics are:
-Green Nudges
-Social Comparison
-Choice Architecture

**Intended Learning Outcomes:**
The objective of the module is to equip the participants with the necessary skill and tools for a successful master thesis project.

Specifically, students will learn to:

- Read and understand recent research contributions
- Develop and pursue interesting research questions
- Conduct a literature review
- Eventually, design and conduct an experimental or empirical study
- Write a seminar paper in which they summarize the literature and explain research methods and results
- Present research findings and defend them in a discussion

**Teaching and Learning Methods:**
In an introductory session, the theme of the seminar is introduced and elaborated in detail.
The introduction will also introduce the relevant behavioral economics literature. Based on the introduction, students will develop their own research question and decide on the adequate research methods. During the term students have to reach different milestones (e.g., choose a topic, choose a research method, collect data, outline their paper, write the paper, present the results) on specific dates. Following the submission of the seminar paper, students will present and discuss their research question and findings. During all stages of the seminar students will be assisted by the lecturer(s).

**Media:**
Research papers; presentation slides

**Reading List:**
Cartwright, E. (2018). Behavioral economics. Routledge.
Davis, D. D., & Holt, C. A. (2021). Experimental economics. Princeton university press.
Additional current research articles will be provided during the seminar

**Responsible for Module:**
Goerg, Sebastian; Prof. Dr. rer. pol.

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

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

# Module Description

## CS0112: Advanced Seminar in Supply and Value Chain Management | Advanced Seminar in Supply and Value Chain Management

Version of module description: Gültig ab winterterm 2023/24

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The examination consists of a written seminar paper, implemented optimization or simulation models as well as an oral presentation & discussion. The seminar paper should cover 15-20 pages and is written in the style of current publications of peer-reviewed journal articles. Accompanied with the seminar paper models have to be implemented to conduct numerical analyses, which will be handed in as a digital appendix. At the end of the module students present their work in a 45 minutes presentation. Weighting: 1:1

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Recommended: One module in the field of Supply Chain Management

**Content:**
The advanced seminar focuses on recent research progress on varying topics in service operations, e.g. omni-channel retailing, online retail management. Students identify strategic and operational relationships between supply chain management, marketing and service functions. Thereby, empirical research methods (such as regression models) are applied as well as mathematical optimization and simulation models (such as mixed-integer programming or discrete event simulation) to identify best practice relationships. Several topics with applications in assortment planning, last mile logistics, transportation, inventory management and procurement are available.

**Intended Learning Outcomes:**
The objective of the module is to equip the participants with the necessary skill and tools for a successful master thesis project.

Specifically, the aim is to be able to:

- Read and understand recent research contributions
- Pursue interesting research questions
- Conduct a literature study and/or numerical study and/or implementation
- Structure and organize research methods and results
- Write a seminar paper
- Present research findings and defend them in a discussion

**Teaching and Learning Methods:**
In an introductory session, the current theme of the module is explained by the lecturer and the various available seminar topics are elaborated in detail. Also information on relevant literature for the problem settings is introduced, wich forms the basis of the students' seminar papers. After the introductory session, students will work out the topic on their own, by using their abbilities of conducting literature research, mathematical modelling, programming and analyses. Throughout the whole time, they receive guidance from a supervisor of the chair. Different milestones are to be achieved at specific dates, such as a preliminary outline of the seminar paper, first research results and the final paper. Following the submission of the final paper, presentations and discussions of all students' seminar papers are conducted, usually spanning one or several days, where amongst others also presentation, moderation and discussion skills are trained.

**Media:**
Research paper; presentation slides

**Reading List:**

**Responsible for Module:**
Alexander Hübner

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Seminar in Supply and Value Chain Management (Seminar, 4 SWS)
Hübner A [L], Hübner A, Riesenegger L, Tuma N
For further information in this module, please click campus.tum.de or here.

# Module Description

## WZ1138: Investment, Financing, Money and Capital Markets | Investition, Finanzierung und Kapitalmärkte

Version of module description: Gültig ab winterterm 2015/16

| Module Level: | Language: | Duration: | Frequency: |
|---|---|---|---|
| Master | | 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:**
Written examination (90 minutes): The students' knowledge is assessed with the help of a comprehensive and coherent case study. This includes students’ ability to make and justify investment decisions as well as identify and justify a required financing for investment measures and a necessary use of guarantees.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge of (financing) mathematics

**Content:**
Investment calculation methods / techniques (static, dynamic), instruments for financing and credit insurance, and debtor related problems will be commented with the aid of case examples.
1. Introduction and basics of investment calculation
2.Taxes in investment calculation
3. Optimum replacement time for investment products
4. Uncertainty and sequential decisions
5. Optimum portfolios
6. Financial planning (involves a field trip)
7. Internal financing and self-financing (involves a field trip)
8. External financing (borrowing and own finance)
9. Loan securities
10. Simultaneous investment and programme planning (field trip)
11. Detailed real-life cases

The analysis of case examples is required to ensure that students can make investment decisions independently in their future professional life and will be able to identify the most suitable forms of financing. Ideally, this is not taught in actual classes but by e-learning (individual and group work; chat; fora, students monitoring their own learning)

Individual excursions (to companies and/or financial institutes) offer additional real-life experience.

**Intended Learning Outcomes:**
Students who have completed this module are aware of the principal methods of static and dynamic investment calculation, including their respective advantages and disadvantages. They can apply those methods to a business context, taking tax into account and using a spreadsheet program.
They are able to calculate and analyze investments offered by companies and derive recommendations for selecting the best offer (from a range of offers).
Students also recognise the potential of companies' internal and external financing (including on the capital market) and the key types of loan securities. They are able to undertake financial planning and evaluate how that might be implemented in a business setting as well as analyse the correct use of common securities relative to the value of the loan.

**Teaching and Learning Methods:**
Blended Learning inclucing 50 % presence required (lectures, tutorials) and 50 % e-learning (via vhb) with the aid of online exercises, a case study and online tutorials.
Teaching of methods via our own e-learning system (developed for vhb) (starting SS2015) as well as in addition to traditional lectures requiring the students' presence.

**Media:**
Blackboard, PowerPoint,
e-learning (via vhb) (script, blog, exercise sets)

**Reading List:**
Bodmer, U.: Geldanlage und Finanzierung. Ulmer Verlag. Stuttgart. 1998.
Drukarczyk, J.: Finanzierung. 10. Auflage. Lucius & Lucius. Stuttgart 2008.
Sachs, G.: Technik der Finanzplanung. In: Hauschildt et al. (Hrsg.): Finanzplanung und Finanzkontrolle. Hagener Universitätstexte. Verlag Vahlen. München.
Zantow, R.: Finanzwirtschaft des Unternehmens; Pearson Verlag.
Zellweger, Th. und U. Fueglistaller: Finanzielles Risiko- und Investitionsverhalten von Familienunternehmen. In: Ernst Young AG und P. Bühler (Hrsg.):Schriften des Family Business Center der Universität Sankt Gallen.2005.
Zellweger, Th. und U. Fueglistaller: Rendite und Spielregeln in Familienunternehmen. In: Ernst Young AG und P. Bühler (Hrsg.):Schriften des Family Business Center der Universität Sankt Gallen.2005.

**Responsible for Module:**
Ulrich Bodmer (ulrich.bodmer@mytum.de)

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

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

# Module Description

## CS0171: Project Studies | Project Studies

Version of module description: Gültig ab summerterm 2021

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>German/English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>12 | **Total Hours:**<br>360 | **Self-study Hours:**<br>330 | **Contact Hours:**<br>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 in (30 pages + appendix) and a 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. Throughout this process, the students show that they can develop appropriate strategies to cope with 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. 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. The project study and its findings regarding the outlined problem set are based on students' academic knowledge gained through their study programs.

Examples of topics covered in the context of a project study include (non-exhaustive list):
- Analyzing potential sales volumes of a new market
- Identifying potential optimization actions regarding a supply chain
- Creating a financing concept for a company
- explaining problems of the logistic sector and developing appropriate optimization solutions
- Developing specific use cases for new electronic payment procedures and deriving appropriate product specifications
- Capturing and processing key performance indicators (KPIs) in controlling and the development of recommended actions
- Developing and conceptualizing a marketing strategy and deriving recommendations for implementation in the given market- or company environment

**Intended Learning Outcomes:**
After successful participation in the module, students are able to work on projects in a systematic and academic manner. Students are able to complete a project end-to-end throughout all project stages: problem definition, division of work/tasks, development of solutions, decision-making processes, realization, result presentation, and project report. Students obtain capabilities to apply theoretical concepts to the identified problem set and develop their analytical solution finding skills through team discussions. Students are able to exchange in a professional and academic manner within a team. They are able to integrate involved persons into the various tasks considering the group situation. Furthermore, the students obtain competencies in solution processes through their constructive and conceptual acting in a team. Students become able to manage resources, and deadlines through timely submission of the enumerated tasks in stages throughout their research projects.

**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. The supervision takes place through a kick-off meeting as well as an interim meeting. With regards to content the project study takes an approximate time of 9 weeks.

**Media:**
literature, presentations

**Reading List:**
Project Management Institute (2013): A Guide to the Project Management Body of Knowledge (PMBOK® Guide) - Fifth Edition

Further literature based on the specific topic

**Responsible for Module:**
Alexander Hübner

**Courses (Type of course, Weekly hours per semester), Instructor:**
Projektstudium | project studies (Orientierungsveranstaltung, 1 SWS)
Hübner A [L], Hübner A, Lex E
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0177: Discrete Event Simulation | Discrete Event Simulation

Version of module description: Gültig ab winterterm 2023/24

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>135 | **Contact Hours:**<br>75 |

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

**Description of Examination Method:**
The examination consists of two individual tasks and a project work. The individual work is done as homework and is composed as follows:
• R-Statistics homework (10 % of the evaluation)
• AnyLogic homework (10 % of the evaluation)

The project work serves to evaluate the understanding in handling and application of simulations. For the project work the participants receive a randomly assigned extensive fictitious simulation problem. The project work consists of the presentation of the project plan, a project report, an oral presentation of 20 min and a discussion time of 10 min.

The evaluation of the project work is based on the following criteria:
• presentation of the project plan (10 % of the evaluation)
• written documentation of the project work (50% of the evaluation)
• presentation and discussion of the project work (20% of the evaluation)

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basic knowledge in mathematics and statistics, especially in probability theory and probability distributions as well as descriptive and inductive statistics

**Content:**
• Basics of simulation
• Steps in a Simulation Study
• Conceptual Modeling
• Introduction to ARIS: Representation of processes using event-driven process chains

• Data collection and modeling of input data
• Introduction to R: Analysis of distributions
• Modeling and implementation of simulation models
• Introduction to simulation software (e.g. AnyLogic) and basic as well as advanced simulation techniques
• Visualization of simulations
• Verification, Validation and Calibration of a simulation
• Methods for determining the simulation setting
• Statistical methods for the analysis of simulation results

**Intended Learning Outcomes:**
Students
• apply their knowledge of probability theory and probability distributions
• are able to analyze production and logistic systems, represent processes and design proposals for optimization.
• apply the necessary methodological knowledge for the independent execution of simulation studies.
• are able to apply simulation software such as AnyLogic practically.
• can present results of a simulation study and derive concrete recommendations for action from their analyses.

**Teaching and Learning Methods:**
The module consists of a lecture and an exercise, which take place weekly. In the lecture, the contents are derived together with the participants. The exercise repeats the lecture contents with examples and deepens core concepts through independent simulation and computational studies of selected problems. The students are supported in solving the exercises by the tutors.

**Media:**
Presentations, cases and solutions

**Reading List:**
• Kelton, W. D., R. P. Sadowski, and D. T. Sturrock, Simulation with Arena, 3. Aufl., Boston (McGraw-Hill) 2003.
• Law, A. M. and W. D. Kelton, Simulation Modeling and Analysis, 4. Ed., Boston (McGraw-Hill) 2007.

**Responsible for Module:**
Alexander Hübner

**Courses (Type of course, Weekly hours per semester), Instructor:**
Discrete Event Simulation (Lecture) (Vorlesung, 2 SWS)
Schäfer F [L], Schäfer F, Tuma N

Discrete Event Simulation (Exercise) (Übung, 2 SWS)
Schäfer F [L], Schäfer F, Tuma N
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0176: Service Operations | Service Operations

Version of module description: Gültig ab winterterm 2021/22

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

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

**Description of Examination Method:**
• The examination is carried out in the form of a written test. This should demonstrate that the students can formulate quantitative decision models in the service sector and solve them with suitable methods.
• Type of examination: written
• Exam duration: 60 minutes

**Repeat Examination:**

**(Recommended) Prerequisites:**
Content of the module „Operations Research" is recommended

**Content:**
• The basic concepts are presented with slide-based lectures. The quantitative models and methods are presented and illustrated by means of examples. Practical applications of service management, e.g. for hospitals, airlines, retail or the service sector.
• These contents form the basis for a critical consideration from a theoretical-conceptual and practical-application-oriented point of view. Current research papers and system-supported case studies are used for this purpose.
• In addition to an introduction to service management, the course also includes location planning, quality management, benchmarking, methods of process optimization, personnel planning, inventory planning and revenue management in the service sector.

**Intended Learning Outcomes:**
• The students get to know quantitative methods of operations management in the service sector and their application in practice.

• The students learn and understand the basic models and methods for service operations management (especially quality and process management as well as capacity planning) and revenue management (especially price differentiation, capacity control, overbooking control and dynamic pricing). It is also about getting to know the possibilities and limits of the models for use in practice.
• The students deepen their knowledge with regard to the modeling and solving of decision problems in the decision fields mentioned above.

**Teaching and Learning Methods:**
The basic concepts are presented with slide-based lectures. The quantitative models and methods are presented and illustrated by means of exercise examples, including practical applications in service management, e.g. for hospitals, airlines, retail or in general in the service sector. These contents form the basis for a critical consideration from a theoretical-conceptual and practical-application-oriented point of view. Current research papers, case studies and textbooks are used as the basis for this.

**Media:**
Presentations, black board work, exercise sheets

**Reading List:**
• Fitzsimmons, J.A. und M.J. Fitzsimmons: Service Management – Operations, Strategy, and Information Technology. McGraw Hill, New York, 3. Auflage, 2001.
• Klein, R. und C. Steinhardt (2008): Revenue Management – Grundlagen und Mathematische Methoden, Berlin/Heidelberg, Springer
• Talluri, K.T. und G.J. van Ryzin (2005): Theory and Practice of Revenue Management, Boston, Springer

**Responsible for Module:**
Alexander Hübner

**Courses (Type of course, Weekly hours per semester), Instructor:**
Service Operations (Lecture) (Vorlesung, 2 SWS)
Hübner A [L], Hübner A

Service Operations (Exercise) (Übung, 2 SWS)
Hübner A [L], Hübner A, Lex E
For further information in this module, please click campus.tum.de or here.

## Module Description

# CLA11317: Interdisciplinary Lecture Series Environment: Politics and Society | Ringvorlesung Umwelt: Politik und Gesellschaft

Version of module description: Gültig ab summerterm 2015

| | | | |
|---|---|---|---|
| **Module Level:**<br>Bachelor/Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>1 | **Total Hours:**<br>30 | **Self-study Hours:**<br>15 | **Contact Hours:**<br>15 |

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

**Description of Examination Method:**
A successful accomplishment of 9 academic performances is mandatory for the examination! The examination consists of a short PowerPoint presentation at the end of the semester. The presentation can be created alone or in groups of two. Everyone has to speak one minute.
The examination is ungraded.

**Repeat Examination:**

**(Recommended) Prerequisites:**

**Content:**
The lecture series Umwelt (environment) is an interdisciplinary, public lecture organised by the Environmental Department of the Studentische Vertretung (Student Representatives) of the TU Munich. Experts speak e.g. on technical environmental protection, health, consumer and climate protection. In the summer semester, it offers students the opportunity to learn about the political and social dimensions of current ecological topics and research results at a scientific level.

The lecture series Umwelt (environment) is offered in the winter semester in the module CLA11200 Ringvorlesung Umwelt: Ökologie und Technik (Lecture series on the environment: ecology and technology). It is only possible to gain given credits twice for the lecture series within each study program.

**Intended Learning Outcomes:**
Students are able to follow expert presentations on political and social dimensions of environmental problems and identify core theses and central facts.

**Teaching and Learning Methods:**
Lectures, presentations, discussions

**Media:**

**Reading List:**

**Responsible for Module:**

**Courses (Type of course, Weekly hours per semester), Instructor:**
Out of Sight, Out of Mind? A Journey into the World's Hidden Realities (Ringvorlesung) (Vorlesung mit integrierten Übungen, 1,5 SWS)
Nogueira de Carvalho M, Pahl A, Slanitz A
For further information in this module, please click campus.tum.de or here.

# Module Description

## CLA31900: Lecture Series Environment - TUM | Vortragsreihe Umwelt - TUM

Version of module description: Gültig ab winterterm 2019/20

| Module Level:<br>Bachelor/Master | Language:<br>English | Duration:<br>one semester | Frequency:<br>winter/summer semester |
|---|---|---|---|
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>67 | **Contact Hours:**<br>23 |

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

**Description of Examination Method:**
The examination consists of a poster created in a group of 2-3 people connecting topics from at least two lectures. In order to collect material for the poster, participants have to organize themselves in discussion groups with 5-6 people.
Each discussion group will split into two groupes for the poster. At the end of the semester the poster has to be presented. Every member of the poster group has to speak one minute,
The grade will consist of the poster and its presentation.
Mandatory requirements for the examination
For the 3-ECTS course a successful accomplishment of 16 academic performances is mandatory for the examination!

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
The systematic integration of education for sustainable development at the university is an extremely complex challenge that can only be addressed through a plural and multi-perspective approach. Within the framework of the UNESCO World Programme of Action "Bildung für Nachhaltige Entwicklung“ (BNE; =Education for Sustainable Development), the interdisciplinary lecture series Umwelt - TUM takes place at the TUM Campus Garching, which deals with changing topics in the field of environmental sustainability.

It is organized by the newly founded branch of the environmental department AStA TUM at the Garching campus to promote sustainability awareness at TUM and to offer interested students the opportunity to deal with the topic in more detail.

**Intended Learning Outcomes:**
After successful participation in this module, students are able to understand lectures at a high scientific level and reproduce central statements. Students are able to comprehend analyses of sustainable development and are familiar with formulating their own positions and justifying them in discussions. Furthermore, they know where they can explore the topic of sustainability in more detail on campus, whether in the form of course offerings, internships, projects or thesis.

**Teaching and Learning Methods:**
It consists of six lectures and an organizational meeting at the beginning. Each lecture includes two 40-minute presentations, a 15-minute break and a subsequent 45-minute discussion with the speakers, which is realized in cooperation with the Zentrum for Schlüsselkompetenzen (Center for Key Competencies) of the Faculty of Mechanical Engineering.
The lectures and presentation slides will be uploaded to the online learning platform Moodle.
As homework, students will prepare a short report of the lectures and the discussion session. In addition, introductory and further literature will be addressed to enhance more detailed discussions of the lectures.

**Media:**

**Reading List:**

**Responsible for Module:**
Dr. phil. Alfred Slanitz (WTG@MCTS)

**Courses (Type of course, Weekly hours per semester), Instructor:**
Out of Sight, Out of Mind? A Journey into the World's Hidden Realities (Ringvorlesung) (Vorlesung mit integrierten Übungen, 1,5 SWS)
Nogueira de Carvalho M, Pahl A, Slanitz A
For further information in this module, please click campus.tum.de or here.

## CS_SoM: Electives SoM (max. 18 ECTS) | Electives SoM (max. 18 ECTS)

## Module Description

## WI000100: Advanced Microeconomics | Advanced Microeconomics

Version of module description: Gültig ab summerterm 2019

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

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

**Description of Examination Method:**
Students receive credit for the module after passing a multiple choice exam (written, 120 minutes). Students apply advanced concepts and methods of microeconomics (most notably of expected utility theory and game theory) to concrete decision problems and develop solutions. They show their ability to assess and evaluate decisions under uncertainty and asymmetric information (e.g. on insurance markets) as well as strategic interaction of decision makers (e.g. under oligopolistic competition). Hereby, students demonstrate their capacity for abstraction (thinking in economic models) and concretization (interpreting and applying the results of the model).

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
WI000021 "Economics I (Microeconomics)" OR WI001056 "Principles of Economics"

**Content:**
The module imparts advanced concepts and methods of microeconomics focussing on choice under uncertainty and strategic interaction. It examines markets under asymmetric information and imperfect competition.
• Expected Utility Theory
○ Risk Preferences
○ Insurance Markets
i) Adverse Selection
ii) Moral Hazard
• Game Theory
○ Nash Equilibrium

i) in pure and mixed strategies
ii) in simultaneous and sequential games
iii) in one shot and repeated games
○ Strategic Interaction in Oligopolistic Markets
i) Simultaneous and sequential quantity competition (Cournot, Stackelberg)

**Intended Learning Outcomes:**
Participation in the module will enable the students
• to apply expected utility theory in order to describe and evaluate decisions under uncertainty and/or asymmetric information. They will be capable of
○ analyzing the functioning of competitive insurance markets,
○ assessing market failure arising from asymmetric information,
○ solving problems of incentive compatibility.
• to apply game theory in order to analyze strategic interaction. They will be capable of
○ identifying and assessing equilibria,
○ practicing backward induction,
○ analyzing social dilemmas and coordination problems.
• to conceive policy advice und to evaluate concrete policy measures (e.g. in the field of social security or competition policy).

**Teaching and Learning Methods:**
The module consists of a lecture as well as an exercise course. The lecture content will be conveyed to the students by means of verbal presentation. The exercise course aims to encourage students to independently deliberate the presented economic problems, which are discussed in the lecture and in the relevant literature. In the exercise course, participants apply the acquired knowledge by solving exercises and implementing case studies, partially this process takes place in group work. Moreover, concrete issues raised by students are addressed and online polls are conducted at regular intervals. The polls contain multiple-choice questions similar to those presented in the exam and help course participants gauge their level of performance relative to others.

**Media:**
Text books, script, exercises, online polls, videos

**Reading List:**
- Gravelle, Hugh and Ray Rees (2004): Microeconomics, Pearson
- Jehle, Geoffrey and Philip Reny (2011): Advanced Microeconomic Theory, Pearson
- Kreps, David (1990): A Course in Microeconomic Theory, Princeton University Press
- Osborne, Martin (2004): An Introduction to Game Theory, Oxford University Press
- Shy, Oz (1996): Industrial Organization: Theory and Applications, MIT Press
- Zweifel, Peter and Roland Eisen (2012): Insurance Economics, Springer

**Responsible for Module:**
Feilcke, Christian; Dr. rer. pol.

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

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

# Module Description

## WI000231: Asset Management | Asset Management

Version of module description: Gültig ab summerterm 2021

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

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

**Description of Examination Method:**
The grading is based on an open-book e-test with a duration of 90 minutes. The e-test consists of calculations and multiple choice questions. By answering questions in multiple choice or text form, students have to show that they are able to understand the theory behind Asset Management (e.g. concept of utility and the calculation of basic utility measures, portfolio selection under various constraints, determinants of the capital asset pricing model and other factor models).
Moreover they show their ability to explain the basic models e.g. of portfolio theory.
By performing calculations and elaborating on theoretical considerations, students demonstrate their ability to evaluate and apply the methods presented in the module. They show that they are able to consider asset pricing models.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
MA9712 "Introductory Statistics" (Recommended)
MA9711 "Introductory Mathematic" (Recommended)

**Content:**
The target of the module is to familiarize students with the concept of Asset Management from a theoretical perspective. The module provides the theoretical foundation that is required to understand typical problems in Asset Management and illustrates how to solve these problems effectively by means of the appropriate tools (e.g. Excel Solver).

The following contents are addressed:

- Utility Theory and decisions under uncertainty

- Theory and application of basic models of portfolio theory with a particular focus on portfolio optimization under various contraints in the Markowitz mean-variance framework
- Theory and application of asset pricing models (e.g. Capital Asset Pricing Model, Arbitrage Pricing Theory)
- Theory and application of conditional asset pricing
- Portfolios Performance Measurement

**Intended Learning Outcomes:**
After successful completion of the module, students (1) understand the concept of utility theory (utility functions and link to risk attitudes) and can (2) calculate basic utility measures (absolute risk aversion, relative risk aversion, expected utility, certainty equivalent, risk premium); Students can also (3) explain and apply the basic models of portfolio theory, i.e. they can calculate the optimal portfolio allocation in the Markowitz mean-variance framework for an arbitrary set of asset returns under various constraints. Moreover, students (4) understand the fundamental concept of the Capital Asset Pricing Model and are able to (5) apply the model and its variants introduced in the module and also recognize the shortcomings of this model. Students (6) learn to use other asset pricing models and when to apply them. Finally, students (7) learn the theory, process and methods to measure the portfolios' performance.

**Teaching and Learning Methods:**
The module combines various learning methods:
- Basic knowledge, theoretical concepts and practical examples will be provided through the lecture.
- Controversial discussions and active participation in class are encouraged to deepen understanding of the concepts presented.
- In the exercises, students will apply their theoretical knowledge to concrete
- Demonstration of how to apply portfolio optimization on real-world data by using Excel
- Students will get insights into practice via several guest lecture

**Media:**
Presentation slides, white board

**Reading List:**
Elton, E. J./ Gruber, M. J. (2006): Modern Portfolio Theory and Investment Analysis, USA, Wiley, 7th Edition.

Copeland, T. E./ Weston, J. F./ Shastri, K. (2006): Financial Theory and Corporate Policy, USA, Addison Wesley, 4th Edition.

**Responsible for Module:**
Kaserer, Christoph; Prof. Dr. rer. pol. habil.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Asset Management - Übung (WI000231, englisch) (Übung, 2 SWS)
Chen M

Asset Management (WI000231, englisch) (Vorlesung, 2 SWS)
Kaserer C, Chen M
For further information in this module, please click campus.tum.de or here.

## Module Description

# MGTHN0124: Advanced Seminar Operations and Technology: Research on the Finance and Operations Interface | Advanced Seminar Operations and Technology: Research on the Finance and Operations Interface

Version of module description: Gültig ab summerterm 2023

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

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

**Description of Examination Method:**
This module enables students to understand the financial and operational constraints faced by firms and how these two areas overlap in salient ways. Students with an operations background will be introduced to financing aspects in supply chains and operations, whereas students with a finance background will learn more about the operations implications of financing decisions. Students will have to deeply analyze several critical topics from traditional topics such as moral hazard or information asymmetry problems to novel research directions such as supply chain finance. Upon completion of this module, the students will be able to identify potential challenges by the firms or financial institutions. The students will also develop capabilities to establish the core problems and formulate the necessary objectives and constraints for setting an academic paper/ thesis on the related topic. Moreover, by preparing the discussion for the module, the students will be able to enhance their skills to communicate complicated concepts and dynamics of the research in a comprehensive way.

The presentation on demonstrating one of the problems from the reading material accounts for 20% of the final grade (group grade). A seminar paper on deriving the solution to problems related to those learned throughout the seminar accounts for 80% of the final grade (individual grade). A detailed guide on content and deadline will be given at the beginning of the semester.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Desirable but not mandatory: Production and Logistics, Management Science

**Content:**
Subject-specific content
• Supply chain management
• Finance and Operations Interface

Methodological content (depending on assigned papers and limited to an introductory level)
• Game Theory
• Econometrics

**Intended Learning Outcomes:**
Upon completion of the module, students are able to
• understand the financial and operational constraints faced by firms and how these two areas overlap in salient ways,
• derive and prove given solutions in research studies,
• develop critical perspectives on operational problems and objectives setting with the understanding of how finance matters,
• generate practical insights from research studies,
• and be prepared for writing a master's thesis in the relevant field.

**Teaching and Learning Methods:**
Seminar
This module will be held hybrid to enable the participation of all students who are interested in this topic regardless of their physical location (i.e., there is no need to be present in Heilbronn). Further details will be shared after the final enrollment is confirmed.
Students will be provided with one main text on various topics related to the finance and operation interface. Additional research papers will be given for more specific cases of the theoretic concepts. Each week students will have to be prepared with a set of questions on the topic that would require a comprehensive and thorough understanding of the topic, for example, the dynamics of a model and deriving or proving the propositions. The lecturer will give a short review and facilitate the session while the main discussions will be done by the students to derive the solutions to the given set of questions.

**Media:**
Research papers and further material to be shared via Moodle, hybrid platform

**Reading List:**
Reading for main topics:

Babich, V., & Birge, J. R. (2020). Foundations and Trends at the Interface of Finance, Operations, and Risk Management. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.3693440

Examples of papers that we will discuss (this list is not meant to be comprehensive):

Babich, V., & Hilary, G. (2020). Distributed Ledgers and Operations: What Operations Management Researchers Should Know about Blockchain Technology. Manufacturing & Service Operations Management, 22, 223-240.

Babich, V., Marinesi, S., & Tsoukalas, G. (2020). Does crowdfunding benefit entrepreneurs and venture capital investors? Manufacturing & Service Operations Management, 23(2), 508-524.

Yang, S. A., Birge, J. R., & Parker, R. P. (2015). The supply chain effects of bankruptcy. Management Science, 61(10), 2320-2338.

**Responsible for Module:**
Wuttke, David; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Seminar Operations and Technology (MGTHN0124): Research on the Finance and Operations Interface (Seminar, 4 SWS)
Choi D, Wuttke D
For further information in this module, please click campus.tum.de or here.

## Module Description

# MGT001345: Advanced Seminar Economics, Policy & Econometrics: Food Governance, Fairness and Sustainability Scientific Writing and Exploratory Research Methods | Advanced Seminar Economics, Policy & Econometrics: Food Governance, Fairness and Sustainability Scientific Writing and Exploratory Research Methods

Version of module description: Gültig ab summerterm 2022

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

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

**Description of Examination Method:**
Grading will be based on a written report (consisting of a research protocol and related research findings) and an oral presentation (20 min) with subsequent discussion, both with an individual and a teamwork component. Both the written report and the oral presentation are worth 50% of the grade. The report and the oral presentation will demonstrate that students have gained in-depth knowledge on how to conceptualize, plan and conduct a research project. It will thus show that students are prepared to write their Master Thesis.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Knowledge in microeconomics

**Content:**
The module deals with issues of governance, fairness and sustainability in the food system.
Key topics of the module may thereby include:
- Locks-ins and levers for facilitating a transitions toward more sustainable food systems;
- Food labels (origin-based labels, animal welfare labels);
- Food quality standards;
- Potential paths for a transition to more sustainable food systems
- Private and public governance in food sectors
- Fairness in business relationships
- European and national regulations and policies concerning the food sector

From a methodological point of view, the focus of this module is on
- Exploratory and Qualitative research methods
- Scientific writing skills

**Intended Learning Outcomes:**
After successful completion of this module, students will have in-depth knowledge on how to conceptualize, plan and conduct a research project concerning good governance, fairness and sustainability in agro-food systems. Moreover, students will be able to i) identify and structure a research topic, ii) build a conceptual framework for qualitative research; iii) applying qualitative research methods to a concrete research question; iv) develop a study instrument; v) conduct interviews for qualitative research; draft a scientific research report. The module thereby prepares students for the scientific work to be conducted in their master theses.

**Teaching and Learning Methods:**
The module is a seminar and provides students with in-depth knowledge of governance, fairness and sustainability grounded in economic theory. The seminar includes a set of lectures on governance, fairness and sustainability.
Guided by the instructor(s) through the entire process, students will work alone and/or in groups around a topic in governance, fairness and/or sustainability.
Activities are carried out in parallel in coordination with foreign universities and students will have the opportunity to collaborate and exchange with students from those universities. The course takes place online.
Together with “Advanced Seminar Economics & Policy/Life Sciences & Management – Food system governance, fairness and sustainability, Literature Review and Presentation Skills”, this module offers a comprehensive toolkit to prepare students for their master thesis as well as for a career in science.

**Media:**
PowerPoint presentations, economic textbooks, scientific articles

**Reading List:**
Barathova, K., Cacchiarelli, L., Di Fonzo, A., Lai, M., Lee, H., Menapace, L., ... & Vandervelde, S. (2020). Pass-through of unfair trading practices in EU food supply chains: methodology and empirical application.
Bowie, N. E. (1988). Fair markets. Journal of Business Ethics, 7(1-2), 89-98.
Denzin Lincoln 2017 The SAGE Handbook of Qualitative Research
Gentile, E., Loi, A., Gentile, M., Bruni, M., Berisio, S., Parisi, P., ... & Rieger, L. (2020). Evaluation of Marketing Standards contained in the CMO Regulation, the “Breakfast Directives” and CMO secondary legislation. Final report.
James, H. S. (Ed.). (2013). The ethics and economics of agrifood competition (p. 99). Dordrecht, Netherlands: Springer.
Kvale 1996 Interviews: An Introduction to Qualitative Research Interviewing
Miles Huberman Saldaña 2014 Qualitative Data Analysis: A Methods Sourcebook

Russo et al. (2021) Upfront Costs as Coordination Devices in the European Agri-Food Value Chain, forthcoming.

**Responsible for Module:**
Menapace, Luisa; Prof. Ph.D.

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

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

# Module Description

## MGT001345: Advanced Seminar Life Sciences, Management & Policy: Food Governance, Fairness and Sustainability Scientific Writing and Exploratory Research Methods | Advanced Seminar Life Sciences, Management & Policy: Food Governance, Fairness and Sustainability Scientific Writing and Exploratory Research Methods

Version of module description: Gültig ab winterterm 2022/23

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

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

**Description of Examination Method:**
Grading will be based on a written report (consisting of a research protocol and related research findings) and an oral presentation (20 min) with subsequent discussion, both with an individual and a teamwork component. Both the written report and the oral presentation are worth 50% of the grade. The report and the oral presentation will demonstrate that students have gained in-depth knowledge on how to conceptualize, plan and conduct a research project. It will thus show that students are prepared to write their Master Thesis.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Knowledge in microeconomics

**Content:**
The module deals with issues of governance, fairness and sustainability in the food system.
Key topics of the module may thereby include:
-Locks-ins and levers for facilitating a transitions toward more sustainable food systems;
-Food labels (origin-based labels, animal welfare labels);
-Food quality standards;
-Potential paths for a transition to more sustainable food systems
-Private and public governance in food sectors
-Fairness in business relationships
-European and national regulations and policies concerning the food sector

From a methodological point of view, the focus of this module is on
-Exploratory and Qualitative research methods
-Scientific writing skills

**Intended Learning Outcomes:**
After successful completion of this module, students will have in-depth knowledge on how to conceptualize, plan and conduct a research project concerning good governance, fairness and sustainability in agro-food systems. Moreover, students will be able to i) identify and structure a research topic, ii) build a conceptual framework for qualitative research; iii) applying qualitative research methods to a concrete research question; iv) develop a study instrument; v) conduct interviews for qualitative research; draft a scientific research report. The module thereby prepares students for the scientific work to be conducted in their master theses.

**Teaching and Learning Methods:**
The module is a seminar and provides students with in-depth knowledge of governance, fairness and sustainability grounded in economic theory. The seminar includes a set of lectures on governance, fairness and sustainability.
Guided by the instructor(s) through the entire process, students will work alone and/or in groups around a topic in governance, fairness and/or sustainability.
Activities are carried out in parallel in coordination with foreign universities and students will have the opportunity to collaborate and exchange with students from those universities. The course takes place online.
Together with “Advanced Seminar Economics & Policy/Life Sciences & Management – Food system governance, fairness and sustainability, Literature Review and Presentation Skills”, this module offers a comprehensive toolkit to prepare students for their master thesis as well as for a career in science.

**Media:**
PowerPoint presentations, economic textbooks, scientific articles

**Reading List:**
Barathova, K., Cacchiarelli, L., Di Fonzo, A., Lai, M., Lee, H., Menapace, L., ... & Vandervelde, S. (2020). Pass-through of unfair trading practices in EU food supply chains: methodology and empirical application.
Bowie, N. E. (1988). Fair markets. Journal of Business Ethics, 7(1-2), 89-98.
Denzin Lincoln 2017 The SAGE Handbook of Qualitative Research
Gentile, E., Loi, A., Gentile, M., Bruni, M., Berisio, S., Parisi, P., ... & Rieger, L. (2020). Evaluation of Marketing Standards contained in the CMO Regulation, the “Breakfast Directives” and CMO secondary legislation. Final report.
James, H. S. (Ed.). (2013). The ethics and economics of agrifood competition (p. 99). Dordrecht, Netherlands: Springer.
Kvale 1996 Interviews: An Introduction to Qualitative Research Interviewing
Miles Huberman Saldaña 2014 Qualitative Data Analysis: A Methods Sourcebook

Russo et al. (2021) Upfront Costs as Coordination Devices in the European Agri-Food Value Chain, forthcoming.

**Responsible for Module:**
Menapace, Luisa; Prof. Ph.D.

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

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

## Module Description

### MGT001435: Impact Entrepreneurship for Transformational Change | Impact Entrepreneurship for Transformational Change

Version of module description: Gültig ab winterterm 2023/24

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>German/English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>9 | **Total Hours:**<br>270 | **Self-study Hours:**<br>190 | **Contact Hours:**<br>80 |

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

**Description of Examination Method:**
The examination consists of three components. In the accompanying online course, the content of the respective units is tested and deepened through reflection tasks and research tasks. This part represents 20% of the grade. Furthermore, the presentation prepared by the students at the end of the semester and its corresponding documentation (pitch deck or similar) is part of the examination (40%). A final report must also be submitted (also 40%).

As part of a final event, the teams present a solution idea for the problem they have chosen and developed in the area of society, ecology or technology. The presentation lasts 5-10 minutes. The students demonstrate that they are able to translate the information they have received into an independently developed impact-orientated business model and present this in an appropriate manner. They are supported in their preparation by regular feedback from lecturers and coaches.

The third part of the grade results from the final report. It documents in a structured way how the information received and the tools presented for working on an impact-orientated business model were implemented. Furthermore, the feedback received during the final presentation should be taken into account and incorporated. The report ensures that the students go beyond mere documentation of their results to structure and reflect on them. The final report should not exceed 7500 characters and must be submitted up to eight weeks after the end of the semester.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
- Basic understanding of entrepreneurship and its principles, such as from attending an introductory lecture on the topic, founding experience, or closely following the media on the topic
- Basic knowledge in sustainability

- Interest in developing innovative solutions from a systemic perspective to generate social and environmental impact

**Content:**
As part of the course, students from various disciplines spend a semester working intensively on social, ecological or technological challenges and the question of how these can be solved with the help of social and innovative business ideas.

The programme teaches methods and knowledge on topics such as system innovation, design thinking, future thinking, regenerative and impact-oriented business models, impact management and financing. The systemic perspective is of particular importance in the programme. In particular, the major social and ecological problems of our time cannot be solved in isolation as "wicked problems". Solutions are therefore only possible by viewing them as phenomena that are integrated into systems.

Students work in teams on social, ecological or technological challenges and apply the methodological knowledge they have acquired to develop an entrepreneurial solution for the selected problem. This process is structured and supported by lecturers and external coaches.

At the end of the semester, the students present the solutions they have developed in the form of impact-orientated business models. In this context, they receive feedback and the opportunity to apply for follow-up coaching for the business ideas they have developed. The final report reflects on the process they have gone through and structures the results.

The course is held in German in the summer semester and in English in the winter semester.

**Intended Learning Outcomes:**
The aim of the module is to enable students to develop practice-oriented solutions in the form of impact-oriented business models. The focus is on generating impact in the sense of the United Nations Sustainable Development Goals. Students will be able to

- explain the concept of impact and its implications and illustrate them using specific case studies.
- develop entrepreneurial solutions for real challenges in interdisciplinary teams.
- apply tools and methods from the fields of systems thinking, future thinking, human-centred design, impact orientation and business modelling to their challenges.
- present the solutions developed for their challenges using professional presentation techniques appropriate to the target group.
- categorise and discuss alternative economic models such as the Economy for the Common Good, Doughnut Economics and post-growth approaches.

The module focuses on experience-based and problem-oriented learning and aims to promote the development of social and entrepreneurial innovations as well as the promotion and development of students' skills with regard to responsible entrepreneurship. By developing solutions in interdisciplinary teams, students also improve their soft skills such as creativity, perseverance, communication skills, and interdisciplinary competences.

**Teaching and Learning Methods:**
Lectures and interactive, seminar-style teaching in the form of discussions, group work, development of challenges, team coaching sessions, feedback discussions, presentations, and Q&A sessions. The variety of methods ensures that the right method is chosen for each learning content to be taught. For example, new knowledge and tools are presented by experts in the field in keynote speeches and then discussed in large or small groups before being incorporated into the development of solutions. Feedback discussions and team coaching sessions facilitate the application of the tools and methods presented. The final presentation at the closing event gives participants the opportunity to practise their communication skills and improve them through appreciative, constructive feedback. The synchronous online and face-to-face teaching is supplemented by asynchronous elements of self-learning time via the accompanying online course and associated reflection tasks, as well as by self-organised project group meetings, which are documented in the final report.

**Media:**
Videos, presentations, online materials, quiz, exercise sheets, Power Point, flip charts, mural boards

**Reading List:**
Meadows, Donella: Thinking in Systems, Earthscan, 2009
Stroh, David Peter: Systems Thinking For Social Change: A Practical Guide to Solving Complex Problems, Chelsea Green Publishing, 2015
Kurz, B./ Kubek, D.: Social Impact Navigator, Phineo, 2017, verfügbar auf https://www.social-impact-navigator.org/

**Responsible for Module:**
Alexy, Oliver; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Impact Entrepreneurship for Transformational Change (MGT001435, deutsch) (Seminar, 4 SWS)
Alexy O [L], Alexy O ( Kaoui V, Vogel C )
For further information in this module, please click campus.tum.de or here.

# Module Description

## MW2245: Think. Make. Start. | Think. Make. Start. [TMS]

*Build innovative products of your ideas in 10 days!*

Version of module description: Gültig ab winterterm 2024/25

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

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

**Description of Examination Method:**
The module examination consists of a project work incl. written documentation (approx. 10 pages) and presentation (10 min), in which the students develop a new product in a group project and present their idea for founding a company on this basis. The individual performance is assessed to what extent the students are able to develop a product with market potential by means of an iterative approach to prototypical implementation. The assessment also includes the ability to work in a team, the ability to make well-founded design decisions and the completeness and conclusiveness of the concept, taking into account social relevance, novelty and innovation. As part of the project work, in addition to documentation, there is a final oral presentation. Through the presentation, students are expected to show whether they can demonstrate their ability to act as a competent team.

**Repeat Examination:**

**(Recommended) Prerequisites:**
The basic requirement is a willingness to engage with new learning methods, approaches, disciplines and ways of working. Cross-role experience in project management, product development (Design Thinking, TRIZ, Systems Engineering, etc), interdisciplinary teamwork, communication skills, creativity and problem solving skills are an advantage. A lot of emphasis is placed on practical experience.

For the "Problem Expert" role, experience in the following areas is an advantage:
- User Testing, Requirements Engineering, Interviewing, Human-Centered Design, Design, Visualisation, Use Case Definition, UX/UI Design, marketing, market research, benchmarking, design thinking.

For the "Tech Developer" role, experience in the following areas is an advantage:
- Hardware (mechanical): design, manufacturing (workshop/makerspace), prototyping, CAD/CAM.
- Hardware (electronic): embedded systems engineering, microcontrollers, sensors/actuators, Arduino, Raspberry, circuitry, board design, metrology, BUS protocols, prototyping, closed-loop/open-loop control, robotics
- Software focus: Backend development, databases, frontend development, machine learning, web development, app development, embedded systems

For the "Business Developer" role, experience in the following areas is an advantage:
- Business Plan/Strategy/Design, Marketing, Sales, Interviewing, Finance & Accounting, Business Law & Regulations, Entrepreneurship.

The number of participants is limited and there will be an application process.

**Content:**
During the interdisciplinary team project, students work methodically, purposefully and agilely on a development project to develop innovative new products with the intention of successfully launching them on the market. Current needs and problems from social, technological and economic systems are identified, analysed and validated in the interdisciplinary team. In doing so, they cooperatively solve challenges that arise from constraints from the different disciplines. They generate suitable market hypotheses and product ideas at an early stage and interact with initial potential customers/users. They iteratively create prototypes and evaluate their hypotheses with them in experiments.

For more information, visit www.thinkmakestart.com and www.tms.tum.de.

**Intended Learning Outcomes:**
After participating in the module “Think.Make.Start.” the students are able to
- reproduce the principles of user-centered design
- apply methods of product development (e.g., Design Thinking) to a challenge of their choice
- develop important hypotheses involving relevant stakeholders (customer, user, ...) through proper planning with "purposeful prototyping"
- examine the relevance of a problem and develop a solution collaboratively in an interdisciplinary team
- design a prototype based on the acquired design methods and analyzed insights
- lay the foundation for one's own business start-up by identifying a start-up idea or team.

**Teaching and Learning Methods:**
"THINK. MAKE. START." is a two-week, practice-oriented, interdisciplinary and competitive teaching format in which students from all faculties can participate (credits are given individually related to the study program). It is organised by the different chairs of TUM, TUM ForTe, and UnternehmerTUM. They get access to the high-tech workshop Makerspace and budget to transform their own ideas into real prototypes (mechatronic products). Learning outcomes are achieved through the following teaching and learning methods:

- Milestones to be achieved, team roles to be held and predetermined course structure provide the roadmap for the project.
- Coaching and teaching expertise in prototyping, business validation, agile development, design thinking, systems engineering, lean startup and user-centred design.
- Teaching the basics of interdisciplinary collaboration through a role concept (Business Developer, Tech Developer, Problem Expert).
- All participants work in interdisciplinary teams (10 teams of 5 students each) and are encouraged to become active themselves and learn through practical experience (hands-on learning).
- Each team pursues a real business idea chosen for the seminar. Special attention is given to really understanding the customer and verifying the solution approach, through questioning, observation, prototyping or expert discussion.
- Using prototyping to bridge the gap between thinking and doing.
- Reflecting on one's own results and approach supports project decisions.
- The teams present their projects to a jury on DemoDay and present the prototypically implemented product ideas to guests from industry, the start-up scene and research.

**Media:**
Project manual, presentations, hand-outs, posters, videos, examples.

**Reading List:**
Esch Franz-Rudolf (2012) Strategie und Technik der Markenführung, 7. Auflage, Vahlen

Faltin, Günter (2008): Kopf schlägt Kapital, Hanser

Halgrimsson (2012): Prototyping and Model Making for Product Design (2012)

Kalweit Andreas, Paul Christof, Peters Sascha, Wallbaum Reiner (2012) Handbuch für Technisches
Produktdesign, Material und Fertigung, Entscheidungsgrundlage für Designer und Ingenieure, 2. Auflage, Springer

Kelly, Tom (2016): The Art of Innovation

Lindemann, U (2007): Methodische Entwicklung technischer Produkte - Methoden flexibel und situationsgerecht anwenden. 2. Auflage

Münchener Business Plan Wettbewerb: Handbuch Businessplan-Erstellung, München http://www.evobis.de/coaching/handbuch/

Malek, Miroslaw / Ibach, Peter K. (2004): Entrepreneurship, Dpunkt Verlag

Moore, Geoffrey A. (2002): Crossing the Chasm, Harpercollins

Osterwalder, Alexander / Pigneur, Yves (2010): Business Model Generation: A Handbook for

Ries, Eric (2011): The Lean Startup

Savoia, Antonio (2019): The right It

Timmons, Jeffry A. / Spinelli, Stephen (2009): New Venture Creation, 7thedition, McGraw, Hill Professional

UnternehmerTUM (2011): Handbuch Schlüsselkompetenzen, 7. Auflage

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

**Courses (Type of course, Weekly hours per semester), Instructor:**
Think.Make.Start. (Praktikum, 4 SWS)
Zimmermann M [L], Tong Y, Hohnbaum K, Amm M, Büchner B, Baur C, Bien S, Mogk J
For further information in this module, please click campus.tum.de or here.

## Module Description

### POL60803: Core Topic: Law and Digitization in Action (MSc. Politics & Technology) | Core Topic: Law and Digitization in Action (MSc. Politics & Technology)

Version of module description: Gültig ab summerterm 2020

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
Students are required to participate in exercises surrounding the meetings. Students have to participate in at least four exercises, three of which will count towards the final grade. Those exercises can be either small tasks like solving a legal problem question in written form or summarizing certain readings (regularly no more than 1000 words). In specific cases, this can also entail oral presentations.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
This module introduces students to the legal techniques of dealing with questions of science and digital technology. The seminar focuses particularly on emergent digital technologies such as artificial intelligence and the internet of things. By tackling one specific and recent topic concerning law, science and technology, the students deepen their knowledge how the law can and does regulate specific situations. They also familiarize themselves with current regulatory debates concerning law and digitisation. Furthermore, they link their findings to general or specific concepts and constitutional principles such as the rule of law, human rights or transparency.

**Intended Learning Outcomes:**
Upon successful completion of this module, students are able to:
- categorize and understand major regulatory and design approaches concerning digital technologies.

- reflect on specific regulatory choices and their intended and unintended impacts.
- display and discuss a legal issue and develop and argue for one solution.
- reflect on the respective choices made in a legal argument and link it to important concepts of constitutional magnitude.
- engage in legal argument in class.

**Teaching and Learning Methods:**
Literature reviews help students to understand and categorize relevant major regulatory approaches and key legal concepts. In-class discussions, including mini moot courts (small argumentative exercises with preconceived roles) and case studies of specific artefacts, train students to display and discuss a legal issue, develop and argue for a solution and provide them with jurisprudential reflection skills. Online videos help them to prepare for classes.

**Media:**
Tba

**Reading List:**
Tba

**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.

## Module Description

### WIB101007: Advanced Topics in Finance & Accounting | Advanced Topics in Finance & Accounting

Version of module description: Gültig ab summerterm 2021

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>German/English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>60 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
A performance record is acquired by a written exam (duration: 60 minutes). For the written exam approaches to digital transformation, current technological developments and processes for the digital transformation of business models will be relevant. Terminology will be checked in the exam with multiple choice questions and open questions, which will require students to apply their learning outcomes from the guest lectures. The presentation and discussion topics between students and speakers will be the basis for the examination questions. Students are only permitted to use a pen, ruler and protractor during the exam.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Advanced understanding of accounting and finance.

**Content:**
The chair of Managerial Accounting/Control, the chair of Financial Management and Capital Markets and the endowed chair in Entrepreneurial Finance offer different courses within this module. Topics of each individual course will be announced by the chairs. Further information will be available on the homepage of each chair.

Possible topics:
- Industrie 4.0
- Digitalization
- Transformation of business models
- Technology development
- Strategy development

- Process design
- Quality and IT-security
- Market development

**Intended Learning Outcomes:**
At the end of the module, students are able to identify and classify different approaches of digital transformation in different companies from large international corporations to medium sized enterprises in different sectors.
At the end of the module, students can evaluate successful business model transformations and compare them with other business model transformations.
At the end of the module, students are able to describe technological developments and asses their potential for the development of new business models.
At the end of the module, students can assess the market with regard to digital business models.
At the end of the module, students can design processes for the digital transformations of business models.

**Teaching and Learning Methods:**
The topics of the module are facilitated through lectures and presentations of guest lectureres from different industry branches. Students are encouraged to study literature of recent topics and deal with problems of concrete examples in teamwork.

**Media:**
Lecture notes, presentation, case studies, discussion.

**Reading List:**
The literature of the module will be available on the website of the chair at the beginning of the semester (http://www.bwl.wi.tum.de).

**Responsible for Module:**
Wildemann, Horst; Prof. Dr. Dr. h.c. mult.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Topics in Finance & Accounting (WIB101007, deutsch): Perspektiven für Wachstum und Wandel (Vorlesung, 2 SWS)
Wildemann H [L], Helmts J, Jensch J, Müller F, Wildemann H
For further information in this module, please click campus.tum.de or here.

# Module Description

## WIHN0012: Digital Finance | Digital Finance [DF]

Version of module description: Gültig ab summerterm 2021

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

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

**Description of Examination Method:**
The module examination consists of a 90-minute written exam, in which the candidates should reproduce the knowledge imparted in the lectures. The students are also required to provide transfer knowledge. It is tested whether students have understood how Digital Finance relates to Traditional Finance and other financial research disciplices; which interdependencies exist among the research disciplines, etc. Dangers and Opportunities of FinTech applications should be understood in detail. Further, students are required to conduct and assess mathematical calculations. The written exam also comprises open questions as well as multiple-choice-tasks.

In addition, by participating in group work studies with presentation on a specific Digital Finance Topic (case study), students have the option to enhance their final grade by up to 0,3. The group studies aim at ensuring a continuous process of learning.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge of corporate finance/financial mathematics is required (e.g. material covered in the course Corporate Finance); joint election with the module "Advanced Seminar in Finance/Accounting: Current Research Topics in Digital Finance" highly recommended

**Content:**
The aim of the course is to give a comprehensive overview on Digital Finance, not covered elsewhere in courses of Corporate Finance within the Master in Management. It provides a coverage of the most recent relevant topics in the field of Digital Finance. Basic knowledge in the field of financial mathematics is a pre-requisite.

The module comprises the most important and most recent developments in Digital Finance. Specifically, it comprises (but is not limited to) the following areas:

- History of Digital Finance and how it relates to other financial research disciplines;
- Robo-Advisors;
- Crowd Funding;
- Peer-2-Peer-Lending;
- Social Media in Finance;
- Digital Payments;
- Cryptocurrencies;
- Digital Technologies (Big Data and Machine Learning; Textual Analysis; Blockchain)
- Cybersecurity;
- Digital Finance and the Market Efficiency Debate;
- The Future of Digital Finance;
- Regulation;
- etc.

**Intended Learning Outcomes:**
The students acquire detailed knowledge on how technological innovations are changing existing financial services and products, their implications and possible applications within the financial industry. Specifically, upon completion of the module, students will be able to identify changes and opportunities of Digital Finance and its implications for the overall macroeconomic stability.

Also, students will be able to fully understand limitations of the digital transformation within the financial industry and its underlying causes. Finally, the students will be able to assess how and why digital finance applications influence the market (in-)efficiency of existing financial markets. In particular, the students are able to analyze complex financial market relations while taking into consideration various influencing factors (as for instance irrational investor behavior).

**Teaching and Learning Methods:**
Types of instruction comprise lecture courses as well as practical courses;

Methods of teaching include lectures, presentations as well as guest lectures;

the learning methods of the students primarily comprise the following activities:
- Follow-up of course contents;
- Exercise and execution of financial calculations;
- Preparation and executation of presentations;
- Ability to answer advanced thematic issues;
- etc.

The chosen types of instruction / methods of teaching are considered adequate to foster/extend the students' ability to fully understand and elaboratethe in-depth the thematic content.

**Media:**
Lecture slides; whiteboard; exercise sheets; exercise portfolio; flipchart; powerpoint; films

**Reading List:**
Due to the topicality of this lecture, the usage of reference books is only in a limited manner possible. Still, the below-listed references are considered as a solid starting point for the contents of this lecture.

Goldstein, I., Jiang, W., & Karolyi, G. A. (2019). To FinTech and Beyond. The Review of Financial Studies, 32(5), 1647-1661.

Blakstad, S., & Allen, R. (2018). FinTech Revolution: Universal Inclusion in the New Financial Ecosystem. Palgrave Macmillan.

Chuen, D. L. K., & Deng, R. H. (2017). Handbook of blockchain, digital finance, and inclusion: Cryptocurrency, FinTech, InsurTech, regulation, ChinaTech, mobile security, and distributed ledger. Academic Press.

Dorfleitner, G., Hornuf, L., Schmitt, M., & Weber, M. (2017). FinTech in Germany. Cham: Springer International Publishing.

Fatas, A. (Ed.; 2019). The Economics of Fintech and Digital Currencies. CEPR Press.

Scardovi, C. (2017). Digital transformation in financial services. Springer.

**Responsible for Module:**
Müller, Sebastian; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Digital Finance (WIHN0012) (Vorlesung mit integrierten Übungen, 4 SWS)
Breitung C, Müller S
For further information in this module, please click campus.tum.de or here.

## Module Description

# WIHN0018: Economics and Management of Platforms | Economics and Management of Platforms

Version of module description: Gültig ab winterterm 2019/20

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

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

**Description of Examination Method:**
Seminar paper with presentation: Each student will be assigned a reader of research papers, book chapters, and case studies to work on. To pass the course, students have to write a seminar paper and present the seminar paper in class.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
very strongly recommend you previously attend an introductory course on economics (e.g., “Principles of Economics”) and management (e.g., “International Management”). Also, the attendance of a course on empirical research methods (e.g., "Empirical Research Methods in Management and Economics") is recommended.

**Content:**
Digital platforms (e.g., Uber, iOS, AirBnB) are transforming entire industries. The drivers of platform markets’ success are complex, and the successful setup and management of a platform requires a sound theoretical understanding of the concepts of network effects, two-sided markets, and complementarity.

The seminar seeks to provide an advanced understanding of the following questions:

- What are digital platforms and how do they impact markets?
- Which economic principles underlie platforms?
- What strategies enable firms to successfully establish platforms?

**Intended Learning Outcomes:**
Knowledge Objectives
After the course, students will be able to:
- Understand the concept of digital platforms from a managerial and economic perspective
- Understand the economic impact of platforms
- Outline the economic principles underlying platforms
- Craft and evaluate strategies for the effective management of digital platforms

Skills Objectives
- Improve diagnostic and analytical skills (i.e., structured problem-solving)
- Build up critical thinking and interpretation skills
- Enhance verbal and argumentation skills via presentations and group discussions

**Teaching and Learning Methods:**
The introductory session will provide an introduction into the key concepts and academic writing in a lecture-style. The largest share of this course will be based on interactive discussions among course participants and based on the presentations of the course participants. A large share of learning will occur through you preparing for the in-class session.

**Media:**

**Reading List:**
- Shapiro, Carl, and Hal R. Varian. Information rules: a strategic guide to the network economy. Harvard Business Press, 1998.
- Parker, Geoffrey G., Marshall W. Van Alstyne, and Sangeet Paul Choudary. Platform revolution: how networked markets are transforming the economyand how to make them work for you. WW Norton & Company, 2016.

**Responsible for Module:**
Förderer, Jens; Prof. Dr. rer. pol.

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

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

## Module Description

### WIHN0020: Empirical Research Project in Finance | Empirical Research Project in Finance

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
The examination comprises a scientific group-based coursework (approx. 30 pages) about a research project, which is supposed to be conducted together with and under the guidance of the lecturer.  In exceptional cases and after consultation, it is also possible to carry out the research project alone in certain cases. The coursework should comprehensively document the research project (research question, literature contribution, data elicitation and data preparation, data analysis, results and interpretation, further research questions). Additional to the written scientific report, candidates are required to showcase main findings within a 30-minute presentation and answer further questions following their presentation.

In doing so, it can be assessed to what extent the students have been able to successfully conduct the research project

The written assigment will be weighted 80% and the formal presentation will make 20% of the final grade. The assessment is based on the groupwork (no indivudual assessment).

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge in corporate finance;
basic knowledge in scientific writing;
motivation letter

**Content:**
The research project is in the field of empirical capital market research and will be announced at the beginning of each semester. The project will be developed and implemented in joint meetings and  on the basis of independent (group-)work.

Candidates are expected to conduct a comprehensive literature review of the most important scientific articles related to the research topic in order to address the given research questions in a systematic and structured manner. It is further expected that candidates learn how to work with capital market databases and mathematical-statistical software packages and learn how to apply appropriate analysis methods.

This modules requires an intensive supervision by and collaboration with the lectures. The maximum number of course participants is therefore set to three. Candidates are chosen on the basis of their motivation letter.

**Intended Learning Outcomes:**
Upon completion of the module, students will be able to …

- conduct an independent literature analysis at the highest possible, international level;
- work with different capital market databases;
- work with different mathematical-statistical software packages and other tools;
- conduct an empirical research project alone and in a research team;
- deriver answers to posed research questions in a systematic and structured manner;
- create/draft a scientific report independently

**Teaching and Learning Methods:**
Types of instruction comprise regular meetings with the lecturer about the current status of the research project and further steps as well as the corresponding main seminar;

Methods of teaching comprise a group-based coursework and the formal presentation of obtained results;

the learning methods of the students primarily comprise the following activities:
- Independent literature research (usage of scientific articles published in international top journals);
- Collaborative Implementation of the research project (research question, literature contribution, data elicitation and data preparation, data analysis, results and interpretation, further research questions);
- Collaborative writing of a scientifc report;
- Exercise of a deductive, logic and consistant argumenation to specifically address and answer the posed research questions;
- Preparation and executation of a final presentation;
- Ability to answer advanced thematic issues

The chosen types of instruction / methods of teaching are considered adequate to foster/extend the students' ability to conduct independent academic work and to elaborate thematically complex contents on their own. It is considered to be a good preparation for the students' master theses.

**Media:**
Exercise sheets, PowerPoint

**Reading List:**

A separate reading list for the research topic will be provided at the beginning of the semester.
To familiarize with the basic software packages and econometric methods the following literature might be useful:

Angrist, J., Pischke, J.-S. (2009). Mostly Harmless Econometrics: An Empiricist's Companion. Princeton University Press.

Gujarati, D., Porter, D., Gunasekar, S. (2009). Basic Econometrics. McGraw-Hill/Irwin.

Kohler, U., Kreuter, F. (2012). Data Analysis Using Stata. Stata Press.

Müller, A., Guido, S. (2016). Introduction to Machine Learning with Python: A Guide for Data Scientists. O'Reilly.

**Responsible for Module:**
Müller, Sebastian; Prof. Dr. rer. pol.

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

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

## Module Description

# WIHN0024: Advanced Seminar Finance & Accounting: Current Research Topics in Empirical Capital Market Research | Advanced Seminar Finance & Accounting: Current Research Topics in Empirical Capital Market Research

Version of module description: Gültig ab winterterm 2019/20

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>165 | **Contact Hours:**<br>15 |

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

**Description of Examination Method:**
The examination comprises a scientific coursework (approx. 20 pages), which is supposed to address the research questions posed within each given seminar topic. The task is to be conducted alone or as a group work (i.e. 2-3 students per topic). It will be communicated in the introductory session if individual work or group work is required (depending on class size). Additional to the written scientific report, candidates are required to showcase main findings within a 30-minute presentation and answer further questions following their presentation.

To maintain the seminar atmosphere, the number of participants is generally limited. If the course is offered in a hybrid format, Munich students may also participate in the course. More information will be provided in the introductory session.

In doing so, the candidates are required to prove that they have dealt with the given topic in a comprehensive manner, that their selection and evaluation of literature is adequate and that they have in-depth analyzed the topic while simultaneously putting it in a higher context of financial research. Also, it can be assessed whether the students are able to answer further questions in a correct and comprehensive manner.

The written assignment will be weighted 2/3 and the formal presentation will make 1/3 of the final grade. Each student will be assessed separately.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge in corporate finance;
basic knowledge in scientific writing

**Content:**
Candidates are supposed to choose one seminar topic out of a set of pre-defined scientific issues. Those topics will be published on Moodle in advance and will be presented in detail during the introduction session.

Candidates are expected to conduct a comprehensive literature review of the most important scientific articles capturing the chosen seminar topic in order to address the given research questions in a systematic and structured manner.

**Intended Learning Outcomes:**
Upon completion of the module, students will be able to …

- exhibit a comprehensive overview on current research topics in the field of Empirical Capital Market Research;
- identify chances and opportunities of these developments (especially with regard to the overall macroeconomic stability);
- conduct an independent literature analysis at the highest possible, international level;
- analyze and evaluate references in a systematic manner;
- combine current topics in Empirical Capital Market Research with theories/methods/models of traditional finance in an independent manner;
- derive answers to posed research questions in a systematic and structured manner;
- create/draft a scientific report independently

**Teaching and Learning Methods:**
Types of instruction comprise an initial lecture (overview course) as well as the corresponding main seminar;

Methods of teaching include an individual work or group work and the formal presentation of obtained results;

the learning methods of the students primarily comprise the following activities:
- independent literature research (usage of scientific articles published in international top journals);
- Collaborative writing of a scientifc report;
- Exercise of a deductive, logic and consistant argumenation to specifically address and answer the posed research questions;
- Preparation and executation of a final presentation;
- Ability to answer advanced thematic issues

The chosen types of instruction / methods of teaching are considered adequate to foster/extend the students' ability to conduct independent academic work and to elaborate thematically complex contents on their own. It is considered to be a good preparation for the students' master theses.

**Media:**
Exercise sheets, PowerPoint

**Reading List:**
Berk/deMarzo (2013): Corporate Finance, 3rd ed., Pearson

A separate reading list for each topic will be provided in the introductory lecture.

**Responsible for Module:**
Müller, Sebastian; Prof. Dr. rer. pol.

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

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

## Module Description

# WIHN0049: Economic Analysis of Contracts, Competition and Companies | Economic Analysis of Contracts, Competition and Companies

Version of module description: Gültig ab winterterm 2020/21

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

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

**Description of Examination Method:**
The examination includes an oral report where the students will present and discuss their work for the seminar paper (30% of the grade). Moreover, students will prepare a seminar paper. In order to support students in writing process, there will be regular discussions about the progression of the project (seminar paper and regular discussions = 50% of the grade). On top of that, students' participation in the classes' discussions of cases will be evaluated (20% of the grade). The active participation in the case discussions measures the students' ability to use the theoretical knowledge of the seminar to analyze real complex situations. The written examination and the corresponding presentation are means to evaluate the student's ability to work with a case, incorporate legal and economic concepts and present a sound study that incorporates the seminar's topics. In the oral report, students also show that they can summarize, academically present, and discuss the subject. Finally, regular discussions with the instructor measure the student's ability to develop an idea, shape it and elaborate a structured project within a given timeframe.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
None

**Content:**
Market structures (perfect competition, monopoly, oligopoly, monopolistic competition)
Anti-competitive practices: horizontal and vertical restraints (dumping, price fixing, cartels, etc.)
European regulation and cases.
Economic criteria to analyze situations related to these topics in business environments.

**Intended Learning Outcomes:**
Students get to know different market structures and their regulation. They acquire elements to analyze and discuss how those structures and the legal mechanisms affect consumers and firms. Participants will gain a basic understanding of contractual structures that are relevant for the economic analysis of the legal framework. Finally, students will learn how to combine their knowledge about topics with the discussion of cases, integrating praxis elements into their analysis. Thus, they can evaluate whether practices in this area are legal and/or economically sensible according to context information.
Argumentative and analytical competencies are strengthened since cases are always open for debate. Their ability to propose creative solutions and work in a team will also be exercised continuously in their work cases.

**Teaching and Learning Methods:**
This seminar presents concepts and tools to analyze competition practices and market structures from a legal and an economic point of view. The seminar integrates a case study with the topics, so students have the opportunity to apply their learnings and implement them in their analysis. Students will study a specific case, expose their understanding, and analyze the case using legal and regulatory elements and economic criteria. Finally, students will present their work in class.

**Media:**
Case studies,exercises, PPT, Whiteboard

**Reading List:**
Mankiw, Principles of Economics (2014); Kovac/Vandenberghe, Economic evidence in EU Competition Law (2018); Posner, Economic Analysis of Law (2014)

**Responsible for Module:**
Jung, Stefanie; Prof. Dr. jur.

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

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

# Module Description

## WI001228: Economics of Environmental and Climate Policy | Economics of Environmental and Climate Policy

Version of module description: Gültig ab winterterm 2019/20

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>150 | **Self-study Hours:**<br>0 | **Contact Hours:**<br>150 |

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

**Description of Examination Method:**
The performance of course participants is examined in form of a written exam (90 minutes) at the end of the semester. Closed, half-open and open-ended questions are used to test whether the students can economically analyze environmental and climate policy measures and explain the environmental policy practice using the New Political Economy. Answering the questions requires own formulations.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
BSc.

**Content:**
Evaluation criteria for environmental and climate policy measures based on welfare economics are used to derive a normatively optimal policy with regard to equity and temporal dimensions. We present economic cost-benefit analysis as a tool for the economic evaluation of environmental and climate protection measures. Subsequently, the suitability of environmental policy measures to overcome specific environmental problems is discussed. We compare a command and control approach with pollution taxes, pollution abatement subsidies and emissions trading. In addition to questions of allocation, the importance of transaction costs and technical progress is discussed. Against the background of environmental risks, the importance of property rights and liability rules is explained. An introduction to the public choice theory is given to explain the implementation of policy measures in practise. We discuss voter models for the analysis of political competition, decision-making rules and voting procedures, as well as the political influence of interest groups and bureaucracy. Against the background of global environmental and climate protection problems, game-theoretical explanations are presented.

**Intended Learning Outcomes:**
In this course, policy measures for environmental and climate protection will be analysed theoretically based on welfare economic approaches whereas the implementation in practice will be discussed based on the public choice theory. The course attendees get to know valuation criteria for environmental and climate policy measures, which take into account temporal dimensions, risk considerations and aspects of equity. After successfully attending the module, the students are able to understand the effects of specific economic policy measures and to evaluate them in terms of welfare economics. With regard to the practical design of environmental and climate policy, the students acquire a comprehensive understanding of how political behaviour, collective decision-making processes and structures can be explained by using public choice theory. Attending the module enables the participants to analyse the individual and collective actions of political actors such as voters, administrations, parties and interest groups, as well as to apply game-theoretical explanations for international negotiations in the context of climate and global environmental problems.

**Teaching and Learning Methods:**
The module consists of lectures. A lecture is a suitable form of imparting the theoretical foundations of environmental and climate policy analysis. The lecturer explains the relevant content; questions from the students can be clarified during the lecture. This ensures that all students get an in-depth insight into the topics at the same level. The students are also encouraged to study the relevant literature.

**Media:**
Slides, Moodle

**Reading List:**
Fees, E (1998): Umweltökonomie und Umweltpolitik.
Beckenbach et al. (2009): Diskurs Klimapolitik.
Tietenberg, T. and L. Lewis (2010): Environmental Economics and Policy.
Kirchgässner (2002): Demokratische Wirtschaftspolitik
Martiensen, J. (2000): Institutionenökonomie.
Weimann J. (1996): Wirtschaftspolitik.

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

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

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

## Module Description

# WI001239: Master Thesis Research Seminar | Master Thesis Research Seminar

Version of module description: Gültig ab summerterm 2020

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

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

**Description of Examination Method:**
The examination consists of a case study / academic elaboration, including a research paper (grade contribution 60%) and in-class presentation (grade contribution 40%). The paper will reveal students' understanding of the necessary theoretical material, methods to perform empirical analysis, and their ability to apply those to analyze real-world situations.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Microeconomics 1

**Content:**
The seminars will review and discuss the concepts of supply chain, decision making under uncertainty, externalities, domestic and international competitiveness, energy transition, carbon neutrality, e-mobility, smart city

**Intended Learning Outcomes:**
Upon successful completion of the course, students will be equipped to perform research needed to complete their master thesis requirements

**Teaching and Learning Methods:**
Presentation of scientific material; in-class discussions of developments and challenges in the automobile industry, analysis and excersices exploring industry related data. Besides simulating company-like environment when students have to identify and solve management and strategic

development problems, the class would teach students to organize their thinking in formal terms and see broad implications of their analysis.

**Media:**

**Reading List:**

**Responsible for Module:**
Ikonnikova, Svetlana; Prof. Ph.D.

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

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

## Module Description

# WI001264: Advanced Seminar Economics, Policy & Econometrics: Decisions under Uncertainty from Description and from Experience | Advanced Seminar Economics, Policy & Econometrics: Decisions under Uncertainty from Description and from Experience

Version of module description: Gültig ab winterterm 2020/21

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

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

**Description of Examination Method:**
Participants will work in small groups.
The formal requirements of this seminar consist of a. giving a presentation in front of their classmates and b. writing a seminar thesis.
For the presentation, participants will select a paper from a range of topics that will be discussed in the introductory lecture.
Participants are expected to be able to identify the key points of this paper as well as to communicate and to defend those points in front of a broader audience in an efficient and succinct way.
For the seminar thesis, participants will build on the paper/topic they selected for their presentation by exploring how the insights from the "Decisions from Experience" paradigm can be applied to the paper's core thesis. In doing so, they are expected to conduct a literature review, propose a research question and develop a study-design through which this question can be empirically tested.
The final grade will be based on the written seminar thesis (70%), but the group presentation of a research topic will allow students to improve their final grade (30%).

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basic understanding of mathematical and statistical principles. Familiarity with microeconomics will be helpful, though not essential.

**Content:**

People very often make decisions under uncertainty regarding future consequences of their actions and their likelihood. Models in Economics often assume that people have full access to numerical descriptions of such uncertainty. In reality, however, people often inform their decisions from past experience. Recently, research in behavioral economics has demonstrated that the two forms of information: from description and from experience, can lead to very different types of decisions. This seminar provides an overview of the standard methods that Economists use to study decisions involving risk as well as the latest insights and methodology for studying such decision when information is obtained from experience. Participants will work in groups in order to prepare a presentation related to the selected topic as well as to develop a paper thesis where they implement the tools and concepts of decisions from experience in order to augment and/or rexamine the finding in the current literature of the selected topic. Each group will select one of the following, broadly defined, topics:
a. Investment decisions b. Tax evasion, cooperation and punishment c. Medical decision making d. Consumer behavior
The seminar will equip participants with tools that are commonly applied in Behavioral Economics, such as theoretical modelling and the key principles of experimental methods.

**Intended Learning Outcomes:**

This seminar aims to 1) equip participants with the state of the art concepts of decisionmaking under risk or uncertainty 2) learn important methodological tools from Behavioural and Experimental Economics 3) develop their presentation skills by communicating the most important insights from their selected topic to their classmates. Moreover, paricipants 4) will practice their ability of conducting literature reviews and deriving important research gaps to their topic and summarize both main insights and research gaps. Finally, 5) participants will exercise their ability to think critically by coming up with an idea to further research in the specified area by enriching standard Economics principles with state of the art insights from Psychology.

**Teaching and Learning Methods:**

This module is a seminar. The introductory meeting will discuss the subtopics, and highlight some seminal findings in the area. In the first phase participants will concentrate on learning by reading relevant scientific literature, presenting one topic per group and discussing questions and interlinkages to related topics. In the second phase, students will produce a written paper in which they need to show their understanding of the respective topic, their capability to identify research gaps in the discussed literature as well as their critical thinking in discussing how an established line of research in Economics - related to the topic the group has selected - can be adjusted through the insights of the decisions from experience program.

**Media:**

Slides, Videos, Zoom-meeting, academic papers.

**Reading List:**
Indicative academic literature (further suggestions based on specific topics will be provided at the beginning of the seminar):

Hertwig, Ralph, et al. "Decisions from experience and the effect of rare events in risky choice." Psychological science 15.8 (2004): 534-539.

Hertwig, Ralph. "The psychology and rationality of decisions from experience." Synthese 187.1 (2012): 269-292.

Thaler, Richard H. "Behavioral economics: Past, present, and future." American Economic Review 106.7 (2016): 1577-1600.

Kahneman, Daniel, and Amos Tversky. "Prospect theory: An analysis of decision under risk." Handbook of the fundamentals of financial decision making: Part I. 2013. 99-127.

Simon, Herbert A. "The sciences of the artificial, 1969." Massachusetts Institute of Technology (1981).

**Responsible for Module:**
Goerg, Sebastian; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Seminar Economics, Policy & Econometrics (WI001264, englisch): Decisions under Uncertainty from Description and from Experience (Limited places) (Seminar, 4 SWS)
Kopsacheilis O
For further information in this module, please click campus.tum.de or here.

# Module Description

## WI001281: The Economics of Firm Competition | The Economics of Firm Competition [EconFirms]

Version of module description: Gültig ab winterterm 2020/21

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

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

**Description of Examination Method:**
A written examination is deemed appropriate to test the ability of students to analyse static and dynamic strategic behaviour of firms. Specifically, it assesses whether students can explain the role of competition, market power and coordination in markets. Students have to prove that they understand and can analyze the impact of firm behavior and industry structure on welfare and evaluate the welfare effects of competition policy. Students will be permitted to use non-programmable calculators during the examination. The exam duration is 90 minutes.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Undergraduate class work in microeconomics or industrial organisation.

**Content:**
The course provides an overview about firm behaviour. Topics discussed include:
• Competition and market power in markets
• The structure of industries and markets
• Strategic interactions among firms
• Vertical relations and coordination in markets
• The effect of firm behaviour on industry efficiency and societal welfare

**Intended Learning Outcomes:**
After successfully completing the module, students will be able:
• To describe the various forms of market structure;
• To explain the role of competition, market power and coordination in markets;
• To apply analytical tools to analyse strategic firm behaviour and interactions;

• To understand the impact of firm behaviour and industry structure on welfare and competition policy.
• To explain coordination and the conditions for efficient coordination.

**Teaching and Learning Methods:**
Application of various teaching methods to optimize structure and rhythm:
• Lecture
• Interactive methods
• Experiments in the lecture
• Discussion of relevant literature
• Exercises

**Media:**

**Reading List:**
Recommended textbook
- J. Church and R. Ware, Industrial Organization: A Strategic Approach, first edition, McGraw-Hill, 2000. (available for free online)

Other suggestions:
1. Jean Tirole: Industrial Organization.
2. Belleflamme and Peitz: Industrial Organization: Markets and Strategies.
3. Motta: Competition Policy: Theory and Practice

**Responsible for Module:**
Menapace, Luisa; Prof. Ph.D.

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

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

## CS_Unternehmer: UnternehmerTUM (max. 6 ECTS) | UnternehmerTUM (max. 6 ECTS)

## Module Description

## WI000285: Innovative Entrepreneurs - Leadership of High-Tech Companies | Innovative Entrepreneurs - Leadership of High-Tech Companies

Version of module description: Gültig ab summerterm 2021

| | | | |
|---|---|---|---|
| **Module Level:**<br>Bachelor | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>60 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
The examination performance is achieved through individual project work, which is divided into three phases. In the first phase, the students intensely engage themselves over a period of six to eight weeks with a self-chosen "Inner Development Challenge" from one of the following topic areas: Relationship to Self, Cognitive Skills, Caring for Others and the World, Social Skills, and Driving Change. Subsequently, in the reflection phase, a written reflection paper is produced in which the students critically reflect on their experiences and draw conclusions for their future.
In the Peer feedback phase, the students read and analyze five reflection papers of their fellow students. This fosters the students' ability to critically analyze their own works as well as the works of others and to give and receive effective feedback.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
- Knowledge: No special requirements, willingness to participate
- Abilities: Identifying opportunities; proactiveness; communication; commitment
- Skills: openness; analytical thinking; visual thinking; self-motivation; networking

**Content:**
The objective of the module is to inspire and motivate the participants coming from various disciplines for an entrepreneurial career, and to give them a basic understanding about founding

and managing technology- and growth-oriented companies. To serve this purpose, the module provides an introduction to the topic of (effectual) entrepreneurship, as well as guest lectures by outstanding founders, entrepreneurs, managers, and investors on selected topics, such as:

1. The entrepreneurial ecosystem
2. Founding of companies for students and scientists
3. How to develop an idea into a market-ready product
4. Financing of startups
5. Corporate growth
6. Creating and managing an entrepreneurial culture
7. Strategic business management
8. Innovation management
9. Corporate finance
10. Business succession

Moreover, for self-motivated participants, there is ample opportunity for personal development through interactive workshops, closed networking events.

**Intended Learning Outcomes:**
Upon successful completion of this module, participants will be able to...
- understand the entrepreneurial mindset
- recognize and develop personal strengths
- develop and implement personal ideas
- understand Design Thinking methodology

Moreover through guest speakers’ lectures and optional workshops participants will be empowered to:
- realize opportunities and challenges associated with the founding and managing of technology- and growth-oriented companies;
- create a personal roadmap for entrepreneurial success.

Thus, students familiarize with topics like opportunity recognition, innovation management, growth, leadership, and the facets of entrepreneurship. In doing that, they are enabled to see, realize, and experience the multiplicity in the everyday life of an entrepreneur, entrepreneurial personalities, as well as entrepreneurial skills and motivations.

**Teaching and Learning Methods:**
As guest lecturers, each week an outstanding founder, entrepreneur, manager, or investor, spanning a wide-ranging industrial spectrum, is hosted to report on their individual entrepreneurial careers.

At the end of each lecture, the participants can actively engage in discussions with the guest speaker during an open session.

Moreover, in context of a workshop, the participants venture their own personal qualities and skills to understand in a structured way their own entrepreneurial identity. In doing that, they focus on their individual strengths and resources to develop a plan to be entrepreneurial.

The module also provides participants with ample opportunity to network with people from the entrepreneurial environment of TUM.

**Media:**
- Lecture slides downloadable
- Online discussion forum (e.g., for questions and feedback on guest lectures)
- Handouts (distributed online)

**Reading List:**
Read, S., S arasvathy, S., Dew, N., Wiltbank, R., & Ohlsson, A. V. (2016). Effectual Entrepreneurship. Taylor & Francis

**Responsible for Module:**
Schönenberger, Helmut; Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Innovative Entrepreneurs - Leadership of High-Tech Companies (WI000285, englisch) (Vorlesung, 2 SWS)
Schönenberger H [L], Schönenberger H, Schuster C
For further information in this module, please click campus.tum.de or here.

## Module Description

# MGT000159: Business Plan - Basic Course (Business Idea and Market) | Business Plan - Basic Course (Business Idea and Market)

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
The examination consists of the preparation of a semester-long project work (business idea) as a team. It consists of the written preparation of a business plan (7-10 pages in length, with specified topic contributions per team member, accounting for 30% of the assessment) and a final presentation (duration: 8 minutes pitch and 8 minutes Q&A, with equaly distributed presentation parts per team member, accounting for 70% of the assessment). The presentation contains, among other things, the most important learnings from the customer interviews and the demonstration of an interactive prototype of the developed product or service.

The project work assesses the extent to which students can identify and implement business opportunities. The business plan presents in a precise and structured way how well the participants have analyzed and understood the needs of their customer. The business plan also examines whether students are able to identify markets for their business idea and analyze market entry opportunities and market positioning. The preparation of initial sales and cost estimates shows whether the students are able to develop a viable business model. In the final presentation, each participant must explain their understanding of this content and defend it in front of the expert jury.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
- Knowledge: No special requirements, willingness to participate
- Abilities: Identifying opportunities; team work; communication; commitment; reliability - Skills: openness; analytical thinking; visual thinking; self-motivation

**Content:**
In iterative, feedback-driven steps, participants learn to think through and present a business idea for solving a customer problem in a structured manner in the form of a business plan. The basic chapters of a business plan listed below are developed for this purpose. The participants network with people from the start-up environment at TUM.

- Brief description of the business idea in the executive summary
- Detailed description of the understanding of the problem, including insights gained from interviews into the needs structure of paying customers and non-paying users
- Detailed description of the developed solution, including documentation of the prototype implementation and substantiation with feedback gained from customers and users
- Comprehensive analysis of the respective market, entry opportunities, competitive analysis and positioning in the market
- Development of a business model suitable for the business idea, including initial sales and cost estimates as well as approaches for successful legal protection

**Intended Learning Outcomes:**
After participating in the module, students are able to
- Identify a real customer problem through feedback, field studies and contextual observations and create a customer benefit with the proposed solution idea
- Recognize opportunities and present prototypical business concepts, e.g. with the help of a business plan
- Evaluate ideas and recognize business opportunities
- Segment markets and identify and characterize potential niche markets
- Develop a business model that includes a clear positioning in the market and a clear differentiation from competitors
- Present their business idea convincingly and based on market data
- Demonstrate the product or service using an interactive prototype

**Teaching and Learning Methods:**
Seminar style: The lecturers are entrepreneurs, serial founders, coaches and former managing directors.
- Interdisciplinarity: Participants form cross-study teams to ensure a target-oriented mix of expertise and skills in the team.
- Action Based Learning: All participants are encouraged to take action and learn through experience and an iterative approach.
- Learning-by-doing: Each team pursues a real business idea or a business idea chosen for the seminar (no case study). Particular attention is paid to really understanding the customer, for example through interviews, observation or expert discussions.
- Prototyping: The teams use interactive prototypes to develop their business idea and make it tangible.
- Online networking: The work in the seminar is accompanied by online tools such as Google Classroom, Slack and Zoom to support the work in the team.

- Peer-to-peer pitching: Each team pitches its idea briefly and succinctly to other teams on the course and receives feedback from them. In this way, the teams get to know different business models and business design approaches.
- Presentation training: Each team presents its business idea several times and receives verbal feedback on presentation style and content.

**Media:**
- Videos
- Slides
- Handouts via the Learning Management System
- Slack as a communication solution for efficient teamwork

**Reading List:**
- Horowitz, Ben (2014): The Hard thing About Hard Things, HarperBusiness
- Kawasaki, Guy (2004): The Art of the Start, Penguin Publishing Group
- Moore, Geoffrey A. (2002).: Crossing the Chasm, HarperCollins
- Osterwalder, Alexander / Pigneur, Yves (2010): Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers, John Wiley & Sons
- Ries, Eric (2011): The Lean Startup, Penguin Books Limited
- Thiel, Peter (2014): Zero to One: Notes on Startups, or How to Build the Future, Crown Business
- Timmons, Jeffry A. / Spinelli, Stephen (2009): New Venture Creation,7thedition, McGraw Hill Professional

**Responsible for Module:**
Bücken, Oliver; Dipl.-Kfm. (Univ.)

**Courses (Type of course, Weekly hours per semester), Instructor:**
Business Plan - Basic Course (Business Idea and Market) (MGT000159, English) (Seminar, 4 SWS)
Heyde F
For further information in this module, please click campus.tum.de or here.

# Module Description

## MGT001347: Innovation Facilitator | Innovation Facilitator

Version of module description: Gültig ab summerterm 2022

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>130 | **Contact Hours:**<br>50 |

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

**Description of Examination Method:**
Combination of group and individual project assignment - final examination consists of two components, each carrying 50% of the final course grade: (1) a 5 minute group presentation plus 10 minutes Q&A and feedback at the end of the course and (2) an individual reflection paper of ca. 2,500 words.
Students will present to the class, the lecturer and the partner how the team identified an attractive opportunity in a suitable market, understood the customers' / users' needs in the process and, as a result, proposed a sustainable business model that balances people, planet and profit.

In a written reflection paper, every student will reflect upon and consolidate their individual learnings from (1) the training on high-performing teams, (2) the reading package and (3) their entrepreneurial experience on three different levels - self, team and entrepreneurship.
As part of the reflection, every student will anonymously read reflection papers of their peers. The peer feedback will foster students' ability to analyze the work of others as well as their own work and to give and receive effective feedback.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Practical experience in applying Design Thinking and Business Design as well as distinct ability to work in a team and great interest in working with individuals and teams

**Content:**
Supported by a training on building a high-performing team and the reading package students will work on five intensive days in interdisciplinary teams on a challenge from a partner and learn why and how to develop customer and user centric business ideas through applying an entrepreneurial mindset and innovative methods -  always considering the triple bottom line.

Taking on an embedded view on the interrelatedness of economic, social and environmental systems, students will develop an ecosystem map to get an overview of relevant stakeholders and potential customers as well as important relationships and value streams. Input on Empathy Research will prepare them to collect qualitative insights from potential customers and users through interviews, immersion and contextual observations.
After conducting their Empathy Research they will step by step learn how to synthesize their insights and define opportunities for sustainable innovation. With a concrete how-might-we-question they will start into ideation. Through different creativity methods they will develop and prioritize ideas and build a simple prototype. This prototype is being tested again through qualitative tests with potential customers and users. When they come back after testing they do a first iteration based on the feedback they got and derive assumptions on a potential business model. After input on pitching they will prepare slides or other material and pitch in front of the group, partner and external guests. After the pitch event they will be led through a reflection of the learnings they gained during the week. The reading package will support the transfer of these learnings.

**Intended Learning Outcomes:**
By the end of the semester students will be able to understand and apply life-centered design principles in the early stages of an entrepreneurial process: from identifying an entrepreneurial opportunity and understanding its environmental and social impact to validating assumptions by applying qualitative research methods and interpreting data as well as using prototyping as a tool for communication and learning. They will be able to apply creativity methods, take over collective responsibility and know how to effectively communicate their business opportunities.
They will have deepened their methodological knowledge in Design Thinking and sustainable business design and have the ability to apply it in following founding projects or a lead role in an innovation team. At the same time, they will have experienced working in a diverse, self-organized team and they will have learned to actively create a setting in which teams can work together effectively by giving and receiving feedback, moderating discussions, defining project goals and reacting to changes.

**Teaching and Learning Methods:**
This module relies on a combination of readings, input sessions, workshops, teamwork and individual feedback and support. While input sessions will stimulate students’ engagement with relevant tools and topics, workshops and team discussions will support the implementation of the knowledge in their projects and facilitate students’ learning of the soft and intricate aspects of adopting an entrepreneurial mindset and skills. Working on a design challenge that a partner (e.g. TUM Venture Labs) provides stimulates peer competition and allows students to directly apply what they learn in a real life setting. The reading package will strengthen students' understanding of the methods and allow them to make sense of their practical experience.

**Media:**
Presentations, Canvas, handywork

**Reading List:**
Each semester students will be provided with a mandatory reading package.

**Responsible for Module:**
Alexy, Oliver; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Innovation Facilitator (MGT001347, englisch) (Seminar, 4 SWS)
Alexy O [L], Hagleitner F
For further information in this module, please click campus.tum.de or here.

# Module Description

## MGT001348: Innovation Sprint | Innovation Sprint

Version of module description: Gültig ab summerterm 2022

| | | | |
|---|---|---|---|
| **Module Level:** Bachelor | **Language:** German/English | **Duration:** one semester | **Frequency:** winter/summer semester |
| **Credits:*** 6 | **Total Hours:** 180 | **Self-study Hours:** 140 | **Contact Hours:** 40 |

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

**Description of Examination Method:**
Combination of group and individual project assignment - final examination consists of two components, each carrying 50% of the final course grade: (1) a 5 minute group presentation plus 10 minutes Q&A and feedback at the end of the course and (2) an individual reflection paper of ca. 2,500 words.
Students will present to the class, the lecturer and the partner how the team identified an attractive opportunity in a suitable market, understood the customers' / users' needs in the process and, as a result, proposed a sustainable business model that balances people, planet and profit.

In a written reflection paper, every student will reflect upon and consolidate their individual learnings from (1) the reading package and (2) their entrepreneurial experience on three different levels - self, team and entrepreneurship.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Interest in entrepreneurship and sustainability, ability to work in a team

**Content:**
Supported by the reading package students will work on five intensive days in Campus only in interdisciplinary teams on a challenge from a partner and learn why and how to develop customer and user centric business ideas through applying an entrepreneurial mindset and innovative methods - always considering the triple bottom line.
Taking on an embedded view on the interrelatedness of economic, social and environmental systems, students will develop an ecosystem map to get an overview of relevant stakeholders and potential customers as well as important relationships and value streams. Input on Empathy

Research will prepare them to collect qualitative insights from potential customers and users through interviews, immersion and contextual observations.
After conducting their Empathy Research they will step by step learn how to synthesize their insights and define opportunities for sustainable innovation. With a concrete how-might-we-question they will start into ideation. Through different creativity methods they will develop and prioritize ideas and build a simple prototype. This prototype is being tested again through qualitative tests with potential customers and users. When they come back after testing they do a first iteration based on the feedback they got and derive assumptions on a potential business model. After input on pitching they will prepare slides or other material and pitch in front of the group, partner and external guests. After the pitch event they will be led through a reflection of the learnings they gained during the week. The reading package will support the transfer of these learnings.

**Intended Learning Outcomes:**
After participating in this module students will be able to understand and apply life-centered design principles in the early stages of an entrepreneurial process: from identifying an entrepreneurial opportunity and understanding its environmental and social impact to validating assumptions by applying qualitative research methods and interpreting data as well as using prototyping as a tool for communication and learning. They will be able to apply creativity methods, take over collective responsibility and know how to effectively communicate their business opportunities.
Taking decisions under uncertainty, ambiguity and risk in newly formed teams will foster their collaboration and communication skills and prepare them for future team work in appreciating and accommodating team members' individual personalities and boundaries.
At the same time the reading package enables students to gain a broader understanding of the methods learned in the course providing them with the ability to apply them beyond the context of innovation.

**Teaching and Learning Methods:**
This module relies on a combination of readings, input sessions, workshops, teamwork and individual feedback and support. While input sessions will stimulate students’ engagement with relevant tools and topics, workshops and team discussions will support the implementation of the knowledge in their projects and facilitate students’ learning of the soft and intricate aspects of adopting an entrepreneurial mindset and skills. Working on a design challenge that a partner (e.g. TUM Venture Labs) provides stimulates peer competition and allows students to directly apply what they learn in a real life setting. The reading package will strengthen students' understanding of the methods and allow them to make sense of their practical experience.

**Media:**
Presentations, canvas, handywork

**Reading List:**
Each semester students will be provided with a mandatory reading package.

**Responsible for Module:**
Alexy, Oliver; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Innovation Sprint (MGT001348, englisch) (Seminar, 4 SWS)
Alexy O [L], Hagleitner F
For further information in this module, please click campus.tum.de or here.

## Module Description

### WI000813: Technology Entrepreneurship Lab | Technology Entrepreneurship Lab

Version of module description: Gültig ab summerterm 2018

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>120 | **Contact Hours:**<br>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 project work.
With the project work students show their understanding of the processes associated with the recognition and development of entrepreneurial opportunities. Students show that they are able to analyze the development of entrepreneurial teams. Moreover, they show their ability to apply coaching tools.
Throughout the project work each student has to hand in regular written documentation of maximum one page in which to describe the continuous development of the entrepreneurial idea as well as the team (60%). At the end of the project work each student has to hand in a summary documentation of maximum three pages (40%) covering idea development, team development and used tools.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
First entrepreneurial experience (in any field)
First team development experience (in any filed)
Ideally already taken part in Tech Challenge (WI 001180) or Business Plan Basic Seminar (WI000159)

**Content:**
In cooperation with UnternehmerTUM GmbH.
The module Technology Entrepreneurship Lab offers a "hands-on-experience" for the development of entrepreneurial business ideas and opportunities with

teams. Students work full-time for three consecutive days on the development of their entrepreneurial, technological and coaching skills. The students document both, the opportunity development process and the parallel team development
process and present both processes. Subsequently, they will work on their teams' development of an opportunity assessment plan for the respective business ideas.

**Intended Learning Outcomes:**
After module participation students are able to understand the processes associated with the recognition and development of entrepreneurial opportunities. In addition, they are able to analyze the development of
entrepreneurial teams and to apply coaching tools for this purpose. Further, they are able to develop an opportunity assessment plan as well as guide others in this process.

**Teaching and Learning Methods:**
The module consists of a three-day introductory lecture on entrepreneurial, technological and coaching skills as well as a hands-on 3 month execution phase with teams. A coach accompanies this process. The business ideas and team development processes are supervised and presented.

**Media:**
PowerPoint, Flipchart, online communication tool, virtual meetings, online webinars

**Reading List:**
Hisrich, R. D./Peters, M. P./Shepherd, D. A.: Entrepreneurship, 8th edition, McGraw-Hill, 2010

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

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

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

# Module Description

## WI000997: Marketing Entrepreneurship Lab | Marketing Entrepreneurship Lab

Version of module description: Gültig ab summerterm 2013

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
The grading is based on a presentation, a reflection paper and participation.
final presentation as a group (40%)
individual written reflection paper (40%)
class participation (20%)
mandatory participation of all
The seminar is on application:
https://academy.unternehmertum.de/programs/marketing-entrepreneurship-lab

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
Learn from Max Wittrock, marketing expert and co-founder of jokolade and mymuesli, practical marketing and business knowledge and apply your marketing skills to real world Start-ups.
At the Marketing Entrepreneurship Lab students get the opportunity to improve their marketing knowledge and apply it to a real world challenge. Support a Start-up of your choice with a course-related project in the areas of strategic marketing, market research, product launch, etc (also possible as a team). The following topics are covered among others in the course:
• How do you create a marketing plan and decide on a strategy?
• How do you measure marketing effectiveness?
• The basics of Public Relations, Storytelling, and Social Media Marketing
• How to plan a Start-up market entry?
• How to balance budget and goals?

• The correlation of startup business models and marketing

**Intended Learning Outcomes:**
Have better understanding of marketing challenges and tools. Enable students to apply their theoretical knowledge about marketing and gain new capabilities in a professional and more practical direction by relating to real life startup marketing challenges.
Equip student with practical skills beyond the traditional marketing curriculum and thus close bridge students with startup founders to better equip them for working in a startup.

**Teaching and Learning Methods:**
lectures
group works
project-based learning
real Start-up cases

**Media:**
hybrid format, blocked seminar, presentation, discussion, clinic

**Reading List:**
will be presented at the start of the seminar

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

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

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

# Module Description

## WI001141: Principled Entrepreneurial Decisions | Principled Entrepreneurial Decisions [PED]

*How to make game-changing decisions*

Version of module description: Gültig ab winterterm 2017/18

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>140 | **Contact Hours:**<br>40 |

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

**Description of Examination Method:**
Mandatory participation on all workshop days
(1) active class participation (25%)
(2) short assignement questions on cases (25%)
(3) presentation of values and principles for their company/project/future startup (25%)
(4) reflection paper, 2-3 pages, max 1.200 words (25%)
The seminar is on application:
https://academy.unternehmertum.de/programs/principled-entrepreneurial-decisions

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Application & willingness for active participation
being or becoming part of a Startup or project team
Students who are interested in Venture Capital and decision-making of founders are also welcome

**Content:**
This course will challenge the next generation of leaders and entrepreneurs to think critically about how their personal values and principles inform the difficult decisions they will have to make as they grow their business. The course will first equip students with frameworks to crystalize their own values and principles. Students will learn to apply their own core values. A selection of readings and case studies will provide students with tangible examples of the challenges other entrepreneurs have faced. Each class will be highly immersive, featuring conversations with entrepreneurial guest speakers and break-out sessions. Through conversations with case

protagonists and each other, students will leave the class more prepared to navigate the ethical dilemmas that they may encounter during their professional lives.

**Intended Learning Outcomes:**
1_students are able to brave difficult situations in the startup context
2_Enable students to begin to craft their own framework – personal and company
3_Discuss case examples (i.e. Flixbus, Konux, ProGlove, Luminovo, fernride, Reactive Robotics, Grupon, buecher.de, SevDesk, inveox, 10X, ...) and conduct exercises to help them on their journey

**Teaching and Learning Methods:**
lectures
group works
role plays
real Start-up cases with the founders in class
discussions

**Media:**
presentations
founders in class
video

**Reading List:**
Dalio, R. (2017). Principles: Life and work. New York, NY
Horowitz, B., & Kenerly, K. (2014). The hard thing about hard things: building a business when there are no easy answers. New York, NY: Harper Business.
More literature will be provided in class

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

**Courses (Type of course, Weekly hours per semester), Instructor:**
Principled Entrepreneurial Decisions (WI001141, englisch) (Seminar, 4 SWS)
Bücken O
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0060: Business Game in Sustainable Management | Business Game in Sustainable Management

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Because of the mediation of competences and the interactive character of the module using the supply chain simulation „The Fresh Connection“ several group presentations are part of the evaluation:
- Introductory presentation for a supply chain topic (30 minutes / 50% of the evaluation)
- Short presentation concerning decision alternatives within a round of the simulation (10 minutes / 20% of the evaluation)
- Presentations of the decisions made within the respective rounds of the simulation, the lessons learnt and the results (15 minutes / 30% of the evaluation)

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Supply Chain Planning

**Content:**
The module is an innovative combination of mediation of theoretical background knowledge, practice and experience using the supply chain simulation „The Fresh Connection“. The topics in detail:
- Basics and decision making in supply chain management
- Supplier Management
- Demand Management
- Capacity and Production Management
- Inventory Management and Planning
- Supply Chain Mapping and component characteristics
- Supply Chain Strategy

- Variables and KPI‘s on strategic and tactical level
- External Collaboration

**Intended Learning Outcomes:**
The students will obtain a practice oriented overview of basics, decisions and interrelations in supply chain management. The students will achieve the ability to understand influencing factors and consequences of supply chain decisions with the help of the simulation “The Fresh Connection“. The students will achieve the competence for autonomous academic self study and application-oriented presentation of content. A focus of the mediation of competences is on work in cross-functional teams.

**Teaching and Learning Methods:**
Lecture, Web-based supply chain management simulation and learning environment, self study and group work with presentation of result

**Media:**
Lecture, simulation software, presentations

**Reading List:**
Fisher, M.L. , What is the right supply chain for your product?, Harvard Business Review, March-April 1997
Christopher, M. , Logistics and Supply Chain Management, creating value-added networks, Prentice Hall, 2005
Chopra, S. and Meindl, Supply Chain Management, Pearson Education, third edition, 2007

**Responsible for Module:**
Alexander Hübner alexander.huebner@tum.de

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

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

# Module Description

## CS0078: Advanced Seminar in Innovation and Technology Management | Advanced Seminar in Innovation and Technology Management

Version of module description: Gültig ab winterterm 2024/25

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The learning results are going to be proved in form of a written thesis. The students write a theoretical and/or empirical thesis of 15-20 pages depedning on the type of current research problem in the area of Innovation and Technology Management. They prove that they have understood the content of the current academic literature and are able to conduct empirical analyses.

**Repeat Examination:**

**(Recommended) Prerequisites:**
Innovation in Bioeconomy

**Content:**
Current research questions from the area of Innovation and Technology Management, e.g., Ecosystems, sustainable innovation, digitization.

**Intended Learning Outcomes:**
After successful completion of the module the students are able to derive an advanced academic research question and to respond to it by using the relevant literature in the area of innovation and technology management. The research questions are typically related to the promotion of sustainable innovation or entrepreneurship within ecosystems. In addition to the required literature analysis based on peer-reviewed academic journals, the students are able to conduct and interpret relevant empirical analyses.

**Teaching and Learning Methods:**
Teaching methods: The students will be familiarized with the basics to conduct literature reviews in the area of innovation and technology management and to conduct and interpret empirical analyses using statistical programs like STATA, R or Python. The students apply these contents to their own research questions in the thesis. The students present their results in front of the other seminar members, and discuss their results with the group.
The students have to write a seminar thesis in order to learn how to write an academic paper based on a relevant research question in the area of innovation and technology management.

**Media:**
Presentations, Power-Point Slides

**Reading List:**
Relevant research papers will be provided

**Responsible for Module:**
Claudia Doblinger claudia.doblinger@tum.de

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Seminar in Innovation and Technology Management (Seminar, 4 SWS)
Doblinger C [L], Doblinger C
For further information in this module, please click campus.tum.de or here.

## Module Description

# CS0096: Advanced Empirical Research Methods | Advanced Empirical Research Methods

Version of module description: Gültig ab summerterm 2024

| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
|---|---|---|---|
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>120 | **Contact Hours:**<br>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 seminar paper with a maximum length of 15 pages. The students analyze a provided data set based on an individually posed question. The results are written down and submitted in the form of a seminar paper that has the structure of a scientific paper. The length of the seminar paper is a maximum of 15 pages. The students should be able to select, justify and implement suitable econometric methods for economic impact assessment based on the given question.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Statistics

**Content:**
Selected statistical methods required for impact analysis in the economics field, e.g. Difference in Difference, Propensity Score Matching, Instrumental Variable Method. Problems of endogeneity and selfselection bias during data collection and analysis. Conception of suitable data collections. The methods will be presented in the lecture. As part of the exercise, its application is carried out on concrete case studies

**Intended Learning Outcomes:**
After attending the module, students will be familiar with the most important statistical methods in the field of Impact Assessment to address the problem of endogeneity and the selfselection bias in economic and social sciences. They are able to select and execute the appropriate statistical models for specific case studies. They know how to collect data themselves in order to perform

such impact assessment. In addition, students are able to understand statistics in scientific literature (peer reviewed journals).

**Teaching and Learning Methods:**
The lecture and exercise will be done using Powerpoint and Stata. In addition, scientifically published studies will be integrated into the lectures. In the exercise, the students themselves analyze data sets that are made available. The results of the case studies are then discussed and questioned individually and / or in groups from different perspectives by the students. Scientific publications using statistical analysis are analyzed and discussed by the students.

**Media:**
Presentations, slide scripts, Articles

**Reading List:**
Kleiber & Zeileis (2008): Applied Econometrics with R, Springer; Angrist & Pischke (2009): Mostly Harmless Econometrics: An Empiricist's Companion, Princeton Univers. Press.

**Responsible for Module:**
Faße, Anja; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Empirical Research Methods (Lecture) (Vorlesung, 2 SWS)
Faße A [L], Faße A

Advanced Empirical Research Methods (Exercise) (Übung, 2 SWS)
Faße A [L], Richter S, Shayo G
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0098: Operations Research | Operations Research

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Assessment takes the form of a written examination. In that examination, students must demonstrate their ability to formulate and solve decision models with appropriate methods. Type of assessment: in writing  duration of assessment: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Bachelor Business administration; advanced knowledge of mathematics and statistics

**Content:**
The module is divided into six distinctive areas:

Part 1: Basic Concepts
Part 2: Quantitative Modelling
Part 3: Linear Optimization
Part 4: Graph Theorie
Part 5: Integer and Combinatorical Optimization
Part 6: Dynamic Optimization

**Intended Learning Outcomes:**
The course introduces fundamental and advanced methods for modeling and solution of business problems with concepts from Operations Research (OR). Students will be introduced to using quantitative methods for planning and decision-making in companies and societies. Students will apply analytical methods of problem-solving and decision-making that is useful in the management of organizations.

**Teaching and Learning Methods:**
Lecture (theory), tutorials with group work and presentation

**Media:**
Seminaristic tution using beamer, overhead projector, flipchart

**Reading List:**
Hilier, F. and Lieberman, G., Introduction to Operations Research, McGraw-Hill, 2009
Kallrath, J and Wilson, J. M., Business Optimisation using mathematical Programming, London (Macmillan) 1997
Winston, W.: Operations Research - Applications and Algorithms. 4th ed. (internat. student ed.), Belmont, Calif. (Duxbury), 2004.
Taha, H. A., Operations Research, 7th ed., Upper Saddle River, N.J. (Prentice Hall) 2003.
Domschke, W., Drexl, A., Klein, R., Scholl, A, Einführung in Operations Research, Berlin (Springer) 2015.
Domschke, W. et al., Übungen und Fallbeispiele zum Operations Research, Springer, Berlin–Heidelberg, 2015

**Responsible for Module:**
Hübner, Alexander; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Operations Research (Vorlesung mit integrierten Übungen, 4 SWS)
Hübner A [L], Hübner A, Riesenegger L
For further information in this module, please click campus.tum.de or here.

## Module Description

# CS0111: Advanced Development Economics | Advanced Development Economics

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
The examination will be given in the form of a written examination. The students should be able to evaluate and justify general and detailed theories, methods and concepts of the environmental and resource economy. Important international examples will be explained. Type of examination: written, no additional tools allowed, duration of examination: 60 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Micro- and Macroeconomics

**Content:**
Why are some countries developing and some are trapped in poverty? What are the determinants of economic growth? What is the role of demography, institutions (in particular the state), the environment, labor, migration, capital or credit markets in the development of states? What is the importance of development aid & cooperation? These are some of the questions that decision-makers in the developed and developing countries have to discuss every day. This course provides a theoretical foundation and empirical evidence for the analysis of the most important questions of today's development of the world.

**Intended Learning Outcomes:**
After visiting the module, the students can use the development economy to understand what is hindering development and what factors lead to success. They can apply theories, concepts, and analytical techniques associated with macroeconomics. Students learn to understand the difference between growth and development, the reasons and impact of migration, the role of institutions (e.g. properte and use rights), development cooperation and international trade. The

students are able to analyze empirical evidence on economic development and to critically read the literature in the field of economic development.

**Teaching and Learning Methods:**
The lecture and the exercise will be done by PowerPoint. In addition, current examples from newspapers and journals will be integrated into the lectures. In the exercise, the students research current case studies linked to the theories and concepts presented in the lecture. These case studies are then individually and / or groupwise discussed and questioned from different perspectives together with the students. Web lectures by internationally renowned experts and researchers will be integrated into the lecture.

**Media:**
Presentations, slide scripts, Articles, online lecture examples

**Reading List:**
Alain de Janvry, Elisabeth Sadoulet (2016). Development Economics - Theory and Practice. Routledge; Michael Todaro, Stephen Smith (2012). Economic Development, Pearson.

**Responsible for Module:**
Faße, Anja; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Development Economics (Lecture) (Vorlesung, 2 SWS)
Faße A [L], Faße A

Advanced Development Economics (Tutorial) (Übung, 2 SWS)
Faße A [L], Faße A, Shayo G
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0113: Innovation in Bioeconomy | Innovation in Bioeconomy

Version of module description: Gültig ab winterterm 2024/25

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>120 | **Contact Hours:**<br>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 written exam (90 Minutes). The written form of the exam allows a comprehensive assessment of students' knowledge and understanding of the principles of innovation management and entrepreneurship with a focus on bioeconomic questions and concepts.  Building on a core understanding of the principles of innovation management and entrepreneurship, students will answer questions about the more recent innovation and entrepreneurship concepts and have the ability to explain the adapted strategies and options for new ventures firms. They will also be able to assess the relevance of technologies and resources related to the bioeconomy and the different options to design sustainable business models in the context of bioeconomic questions.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Entrepreneurship, Introduction to Innovation Management

**Content:**
The module introduces students into advanced principles of innovation management and entrepreneurship from a sustainable perspective. Students will be equiped with basic knowledge on:
- design of business models to implement sustainable innovation
- advanced methods to generate and implement sustainable innovation
- role of ecosystems and networks

Beyond that, students will engage in break-out group workshops to personally experience the process of developing and evaluating sustainable innovation activities. Students give presentations to the audience and discuss their results.

**Intended Learning Outcomes:**
Following the completion of the course, the students will be familiarized with theoretical concepts and empirical methods to:
• assess the different forms and contents for identifiying and organising entrepreneurial ideas and innovative solutions in the context of the Bioeconomy by including broader economic, environmental and societal effects
• derive recommendations about the design and practices of innovation management and entrepreneurship and how to implement sustainable innovation
• identify and evaluate environmental technologies and design scenarios for firms to implement sustainable innovation

**Teaching and Learning Methods:**
The module will combine several learning methods.
- The basic knowledge as well as real world examples and case studies will be provided through the lecture.
- Discussions in the lecture and active participation are encouraged and will contribute to deepen the understanding of the concepts introduced.
- In the tutorial, the academic concepts will be discussed and applied in case studies. The students will further apply (part of) their theoretical knowledge to real-world problems and present their results in teams. This format fosters team work.
- Students will get additional background knowledge from the scientific literature in private reading.

**Media:**
Presentation, Power-Point Slides, Case Studies

**Reading List:**
The reading list is compiled from the latest contributions of relevant scientific journals, including the Academy of Management Journal, Research Policy, Strategic Management Journal, and will be made available to the students.

**Responsible for Module:**
Doblinger, Claudia; Prof. Dr. rer. pol. habil.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Innovation in Bioeconomy (Lecture) (Vorlesung, 2 SWS)
Doblinger C [L], Doblinger C

Innovation in Bioeconomy (Exercise) (Übung, 2 SWS)
Doblinger C [L], Doblinger C, Fischer D
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0114: International Trade | International Trade

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
The examination will be given in the form of a written examination. The students should be able to evaluate and justify general and detailed theories, methods and concepts of the environmental and resource economy. Important international examples will be explained. Type of examination: written, no additional tools allowed, duration of examination: 60 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Micro- and Macroeconomics

**Content:**
Basics of trade theory, such as Gains of Trade are deepened. Effects of customs duties and non-tariff trade barriers, such as environmental standards are presented. It deals with the concept of Pollution Haven and Race to the Bottom. The World Trade Organization and its role in international trade will be presented and discussed on the basis of current trade agreements and conflicts.
In addition, the lecture gives an overview of the effects of trade on international resources consumption. In doing so, empirical trade models (e.g., Gravity Model) are used for clarification.

**Intended Learning Outcomes:**
Students develop an understanding of theories and empirical methods used in the analysis of international trade. They know how trade policy affects the competitiveness and well-being of society and can apply these methods to the core issues of the globalization debate and sustainable trade.

**Teaching and Learning Methods:**
The lecture and the seminar will be done by PowerPoint. In addition, current examples of trade policy from the media and journals will be integrated into the lectures. In the seminar, the students research current case studies on the theories and concepts presented in the lecture. These case studies are then individually and / or groupwise discussed and questioned from different perspectives together with the students. Empirical trade models are used and discussed.

**Media:**
Presentations, slide scripts, Articles

**Reading List:**
Krugman, Obstfeld (2016) International Economics: Theory and Policy, Global Edition; Michael Todaro, Stephen Smith (2012). Economic Development, Pearson.

**Responsible for Module:**
Prof. Dr. Anja Faße

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

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

# Module Description

## CS0117: Consumer Studies | Consumer Studies

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
The examination will be given in the form of a written examination as well as students' presentations. The students should be able to evaluate and use the methods of consumer and market research that were thought in the module. No additional tools are allowed during written examination. Duration of written examination: 60 minutes. The proportion of the written examination is 50% of the total grade.
The students' presentations aim to present the scientific methods and results of a student project elaborated during the semester. The students present individually or in groups the elaborated results and discuss them with their colleagues and lecturer. Powerpoint and presentation equipment are allowed for the presentations. Students must give an intermediate presentation (duration: 10 minutes) and a final presentation (duration: 20 minutes). Students will only be admitted to the final presentation if they have successfully completed the interim presentation The proportion of the presentations is 50% of the total grade.
Both parts of the grade (written examination and presentation) must be passed in order to successfully complete the module.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge in statistics

**Content:**
The content of the module comprises of theory and analysis tools related to consumer behavior as well as their practical implementation. After a general introduction into the theory of consumer behavior the following topics will be covered in the module: consumption models, attitudes, involvement, knowledge, motives, lifestyles and other psychographic constructs. Additionally the students will become familiar with qualitative and quantitative market research methods. Different

survey tools will be introduced for practical implementation. The same is true for statistical data analysis packages (like e.g. SPSS, R) or qualitative analysis tools.
Additionally, the students use the learnt methods and tools to answer selected questions related to consumer behavior in biobased products or products based on regenerative resources.

**Intended Learning Outcomes:**
After attending the module, students will be familiar with the determinants of consumer behavior. They are able to understand and use different methods of market and consumer research. They are able to select and execute various methods of data collection (e.g. surveys, observational methods), to statistically analyse the collected data or use qualitative analysis tools, and interprete the results of the analysis. In addition, students can use the theoretical knowledge that is taught in the module to elaborate and implement own solutions to actual questions in the area of consumer behavior.

**Teaching and Learning Methods:**
The lecture will be done using Powerpoint and and statistic programs to data analysis. In addition, scientifically published studies will be integrated into the lectures. In the students' project, students use the theoretical knowledge and learnt methods of consumer and market research to analyse specific scientific questions related to consumer behavior. Finally, students will present and discuss their approach and results with their collegagues and lecturers.

**Media:**
Presentations, slide scripts

**Reading List:**
Mayring, P. (2014): Qualitative content analysis: theoretical foundation, basic procedures and software solution.
Klagenfurt. https://nbn-resolving.org/urn:nbn:de:0168-ssoar-395173
Backhaus, K.; Erichson, B.; Gensler, S. Weiber, R., Weiber,  (2021): Multivariate Analysis – An Application-Oriented Introduction Berlin, Springer
Hoffmann, S.; Akbar, P. (2023): Consumer Behavior. Berlin, Springer

**Responsible for Module:**
Decker, Thomas; 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

# CS0118: Environmental Accounting in Economics and Sustainability Sciences | Environmental Accounting in Economics and Sustainability Sciences

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
The examination will be given in the form of a written examination. The students should be able to evaluate and justify general and detailed theories, methods and concepts of the environmental accounting in economics. Example problems will have to be explained, solved and discussed. Type of examination: written, no additional tools allowed, duration of examination: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Micro- and Macroeconomics, Advanced Sustainability and Life Cycle Assessment

**Content:**
Fundamentals of the national accounts (input-output analysis) and the extension to environmental and social accounts (NAMEA, Social Accounting matrix). Integration of environmental accounts through physical and monetary environmental accounts and their advantages and disadvantages. Execution of multiplier analyzes with Excel. Use of input-output analysis and its environmental extensions for material flow analysis. Dynamic and multi-regional input-output approaches and hybrid Life Cycle Assessment.

**Intended Learning Outcomes:**
After the module, students will be able to understand and develop the system of national accounts and the integration of environmental accounts (monetary and physical) at national and regional level. They are able to perform and interpret a multiplier analysis. They use advanced methods of input-output analysis to solve problems in material flow analysis.

**Teaching and Learning Methods:**
The lecture and the tutorial will be done by Powerpoint and Excel. In addition, current examples from scientific journals and data sets will be integrated into the lectures. For advanced examples the use of a mathematical software suite such as Matlab and input-output as well as life cycle inventory databases is intended. These case studies are then analyzed and discussed individually and / or in groups from different perspectives together by the students.

**Media:**
Presentations, slide scripts, Articles

**Reading List:**
Taylor (2008): Village Economies: The Design, Estimation, and Use of Villagewide Economic Models. Cambridge University Press; Anguita & Wagner (2010): Environmental Social Accounting Matrices: Theory and Applications, Routledge.  Brunner/Rechberger (2017): Handbook of Material Flow Analysis, CRC Press; Miller/Blair (2009): Input-output Analysis: foundations and extensions, Cambridge University Press; and recent journal articles (to be announced in the lectures)

**Responsible for Module:**
Anja Faße

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

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

# Module Description

## CS0119: Behavioral Public Economics | Behavioral Public Economics

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
The examination will be given in the form of a written examination. The students should be able to describe theories, methods and concepts of Behavioral Public Economics. Students should be able to explain important examples from the academic literature. Type of examination: written, calculators are allowed, no additional tools allowed, duration of examination: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Microeconomics, Advanced Microeconomics

**Content:**
In this course combines public economics with recent contributions of behavioral economics. Students will learn how to apply findings from behavioral economics to the public sector. This course will combine standard models from text books with recent academic papers. We will cover classic theories, their behavioral extensions, and empirical studies. Cover topics will be:
- Welfare Analysis
- Taxation
- Public Goods / Externalities
- Political Economy (Politicians and Voting)
- Public Policy (Savings, Poverty, Health, Environment)

**Intended Learning Outcomes:**
After attending the module, students will understand current topics in Public Economics and know the relevant insight from behavioral economics. They are capable of applying economic theory to analyze current problems and they can reference the relevant empirical evidence. Students can

analyze and evaluate policy proposals. Based on existing examples they can design and discuss their own policy interventions.

**Teaching and Learning Methods:**
The lecture will be mostly done by presentations. In addition, articles from newspapers and journals are integrated into the lectures. Together with the lecturer, students will study the content and methods of the academic papers. In the exercises, students will practice solving the learned models. This will either be done jointly on the blackboard or as work in smaller groups. Classroom experiments are carried out for selected topics.

**Media:**
Presentations, slide scripts, Articles, online lecture examples

**Reading List:**
Atkinson, A. and Stiglitz, J. (1980), Lectures on Public Economics, McGraw-Hill; reprinted by Princeton University Press (2015).
Gruber, J. (2016) Public Finance and Public Policy, 5th edition, Worth Publishers.
Additional references of academic papers

**Responsible for Module:**
Goerg, Sebastian; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Behavioral Public Economics (Exercise) (Übung, 2 SWS)
Goerg S [L], Goerg S

Behavioral Public Economics (Lecture) (Vorlesung, 2 SWS)
Goerg S [L], Goerg S, Speckner M
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0120: Advanced Sustainability and Life Cycle Assessment | Advanced Sustainability and Life Cycle Assessment

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Written exam (90 minutes): Students have to solve problems from the thematic field of the module. They have to prove their ability to use the right vocabulary, apply their knowledge on advanced topics in life cycle and systems thinking, sustainability and and life cycle assessment. Learning aids: pocket calculator.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Fundamental knowledge in Life Cycle Assessment as demonstrated e.g. by the successful participation of the module Material Flow Analysis and Life Cycle Assessment or Principles of LCA.

**Content:**
The module contains units covering the following topics:
• Systems and life cycle thinking
• LCA following the ISO 14040/14044 and ILCD standards
• Extension of Life Cycle Assessment to Life Cycle Sustainability Assessments
• Advanced Life Cycle Impact Assessment Methods such as for
- Land use and land use change
- Water use
- Resource use
• Attributional and consequential assessments
• Regionalisation of inventories and impact assessments
• Hybrid approaches
• Uncertainty handling

• Interface with Multi Criteria Decision Analysis
• Presentation and visualisation of results
• Handling of data uncertainty
• Current trends and developments
• Software systems and data bases for material flow analysis and life cycle assessment
• Case studies

**Intended Learning Outcomes:**
The students use advanced concepts and tools of sustainability and life cycle assessment to assess products, services and processesregarding their environmental impacts. Thus, they are able to gain a deeper understanding of their underlying material and energy flows and how they impact the environment. With these competencies development and improvement of systems, products and services can be supported, decision support delivered and communication with stakeholders aided.

**Teaching and Learning Methods:**
Format: lecture and (computer-based) exercises to introduce the content, to repeat and deepen the understanding as well as practice individually and in groups.

Teaching / learning methods:
- Media-assisted presentations
- Group work / case studies with presentation
- Individual assignments and presentation
- Computer lab exercises using LCA software systems and Life Cycle Inventory Data bases.

**Media:**
Digital projector, board, flipchart, online contents, case studies, computer lab

**Reading List:**
Recommended reading:
• Curran, M.A. (2015): Life Cycle Assessment Student Handbook, Scrivener Publishing:
• Hauschild, M.Z. & Huijbregts, M.A.J. (2015): Life Cycle Impact Assessment (LCA Compendium - The Complete World of Life Cycle Assessment), Springer.
• Klöpffer, W. & Grahl, B. (2014): Life Cycle Assessment (LCA), Wiley-VCH.
• Recent articles from esp. International Journal of Life Cycle Assessment, Journal of Cleaner Production, Journal of Industrial Ecology, Environmental Science and Technology (to be announced in the lecture)

**Responsible for Module:**
Fröhling, Magnus; Prof. Dr. rer. pol.

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

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

# Module Description

## CS0121: Sustainable Production | Sustainable Production [SP]

Version of module description: Gültig ab winterterm 2020/21

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

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

**Description of Examination Method:**
Written exam (90 minutes): By solving problems from the thematic field of the module students have to prove their understanding of the management of industrial production processes and technologies under consideration of sustainability aspects. In doing so they have to prove their techno-economic understanding, knowledge on quantitative methods for the analysis, assessment and optimisation of production systems, as well as their analytical and verbal skills in the field. They need to show that they are able to discuss the treated approaches and to derive further research needs. Learning aids: pocket calculator.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
-

**Content:**
The module covers inter alia the following topics:
• Sustainability aspects of industrial production and consumption
• Reasons for considering sustainability aspects in production management
• Measuring sustainability of production and operations
• Sustainable product and service design
• Sustainable sourcing
• Sustainable production management
• Sustainability of logistics
• Managing wastes, waste water, air emissions and product returns

**Intended Learning Outcomes:**
The module aims at enabling students to approach management tasks of production systems under consideration of sustainability aspects. This covers especially , especially the analysis, assessment and optimisation of these using a quantitative systems analysis approach.

The students understand that production and consumption activities have sustainability impacts and why these have to be considered in the management of production systems. They apply quantitative approaches for the analysis, assessment and optimisation of these systems on example planning tasks. They are capable to discuss the approaches critically, derive further development needs and transfer these approaches to other fields.

**Teaching and Learning Methods:**
Format: Lecture with exercise to introduce, train and deepen the contents of the module.

Teaching / learning methods:
- Media-assisted presentations
- Group work / case studies with presentation
- Individulal assignments and presentation

The teaching and learning methods are combinded specifically for the treated topics. Typically, a thematic impulse or overview is given with a media-assisted presentation. Individual or group work assignments provide the possibility to apply the acquired competencies, to repeat and deepen these as well as to prepare the transfer to other fields.

**Media:**
Digital projector, board, flipchart, online contents, case studies

**Reading List:**
Recommended reading:
• Stark R; Seliger G, Bonvoisin J (2017): Sustainable Manufacturing - Challenges, Solutions and Implementation Perspectives , Springer
• Reniers G, Sörensen K, Vranken K (2013): Management principles of sustainable industrial chemistry, Wiley VCH
• McKinnon A, Browne M, Piecyk M, Whiteing A (2015): Green Logistics, Kogan Page
• Mangla S, Luthra S, Jakhar S K, Kumar A, Rana N P (2019): Sustainable Procurement in Supply Chain Operations, CRC Press

Further related reading, especially articles in international peer reviewed journals, will be provided in the kick-off meeting of the module.

**Responsible for Module:**
Fröhling, Magnus; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Sustainable Production (Vorlesung) (Vorlesung, 2 SWS)
Fröhling M [L], Heinrich V, Schirmeister J

Sustainable Production (Übung) (Übung, 2 SWS)
Fröhling M [L], Schirmeister J, Heinrich V
For further information in this module, please click campus.tum.de or here.

## Module Description

# CS0122: Personnel and Organizational Economics | Personnel and Organizational Economics

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
The examination will be given in the form of a written examination. The students should be able to describe theories, methods and concepts of Personnel and Organizational Economics. Students should be able to explain important examples from the academic literature. Type of examination: written, calculators are allowed, no additional tools allowed, duration of examination: 90 minutes. In order to be admitted to the examination, successful completion of a course assignment is required. In the assignment, students apply what they have learned and demonstrate in a group work that they can understand and present a current research paper.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Microeconomics, Advanced Microeconomics

**Content:**
In this course we develop a simple theoretical framework for thinking about firm-worker interactions (the principal-agent model). We use it to organize the large empirical literature on personnel motivation, personnel selection, and organizations as a whole. The relevant are:
- The principal-agent-problem
- Employee motivation
- Recruiting and wage setting
- Tournaments as incentives
- Teams

**Intended Learning Outcomes:**
After attending the module, students will understand the impact of individuals' incentives in organizations in general and at the workplace as a concrete example. Students will understand how to model diverging motives and incentives and how those may result in conflicts. In addition, they are capable of the interpreting and summarizing the empirical evidence on those topics. Students will learn about possible solutions to align the incentives within organizations and are capable of solving these problems with the help of models.

**Teaching and Learning Methods:**
The lecture will be mostly done by presentations. In addition, articles from newspapers and journals are integrated into the lectures. Together with the lecturer, students will study the content and methods of the academic papers. In the exercises, students will practice solving the learned models. This will either be done jointly on the blackboard or as work in smaller groups. Classroom experiments are carried out for selected topics.

**Media:**
Presentations, slide scripts, Articles, online lecture examples

**Reading List:**
Peter Kuhn, Personnel Economics, Oxford University Press;
Zusätzliches Literaturverzeichnis wissenschaftlicher Publikationen

**Responsible for Module:**
Goerg, Sebastian; Prof. Dr. rer. pol.

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

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

## Module Description

### CS0128: Corporate Sustainability Management | Corporate Sustainability Management [CSM]

Version of module description: Gültig ab summerterm 2023

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

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

**Description of Examination Method:**
Written exam (90 minutes): Students have to solve problems from the thematic field of the module. They have to prove their ability to use the right vocabulary, apply their knowledge on advanced topics in strategic and operational sustainability management.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
None

**Content:**
The Corporate Sustainability Management module includes a detailed discussion of the term sustainability (three-pillar model) and the history of the content. Based on this, the basic premises for sustainable management and sustainable economic activity are derived and discussed in a social, political, environmental, economic and corporate context. The national, European and international strategies for sustainable management are presented (e.g. bioeconomy, circular economy, green economy). Furthermore, established measurement concepts and key performance indicators (KPIs) for sustainability (e.g. resource productivity, life cycle costing) are discussed and applied to exemplary products and value chains within the framework of "Corporate Social Responsibility Reporting".

**Intended Learning Outcomes:**
After completion of the module, the students are able to understand sustainability concepts and to compare sustainability-oriented corporate profiles as a supplement to value-added corporate development. They can develop and apply concepts for the derivation, evaluation and operational integration of economic, ecological and social indicators. This enables the students to carry out

sustainability assessments based on common and innovative new measurement concepts and indicators and to apply the results in the company.

**Teaching and Learning Methods:**
The module includes a lecture and an exercise. During the lecture, the content is communicated by presentations and discussions. The lectures serves to communicate the theoretical basics and terms of sustainability management including small exercises for group work. The students are encouraged to further deepen their knowledge of the proposed literature. As the highest level of competence, the lecture communicates an understanding of the evaluation of various sustainability concepts for use in operational management.
In the exercise, the students deepen the knowledge they have acquired by case studies. The content of the lectures and exercises is deepened both in small working groups and in individual work. As the highest level of competence, the exercise conveys the step-by-step development and incorporation of sustainability concepts using case studies of real and fictitious company concepts to achieve strategic and operational targets for sustainable development of the selected company.

**Media:**
Presentations, slide scripts, case descriptions of real and fictitious companies with sustainability management problems

**Reading List:**
Müller-Christ, G. (2010) Sustainable Management. Introduction into Resource Orientation and Contradictory Management Rationalities. Baden-Baden: Nomos
Schellnhuber, H. J.; Molina, M.; Stern, N.; Huber, V.; Kadner, S. (2010): Global Sustainability. A Nobel Cause. New York: Cambridge University Press
Seliger, G. (2012): Sustainable Manufacturing. Shaping Global Value Creation. Berlin: Springer
Von Hauff, M.; Kleine, A. (2009): Nachhaltige Entwicklung (Sustainable Development). Grundlagen und Umsetzung (Basics and Implementation). München: Oldenburg Wissenschaftsverlag

**Responsible for Module:**
Röder, Hubert; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Corporate Sustainability Management (Exercise) (Übung, 3 SWS)
Röder H [L], Röder H

Corporate Sustainability Management (Lecture) (Vorlesung, 1 SWS)
Röder H [L], Röder H
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0169: Sustainable Supply Chain Management | Sustainable Supply Chain Management

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**

Exam: 50%
presentation: 50%

The combination of grading methods is necessary to evaluate the skills acquired in this course
- Written exam: 45 minutes written exam on presentation, recommended readings, and case studies
- Oral report/presentation: Preparation of an reports in tandem teams with presentation and discussion. The report can be provided as slide-based summary of the presentation. Objective is the preparation of and summary of a current research paper in the field of the lecture; the list of papers is provided at the beginning of the course; All parts have to be passed and cannot be retaken

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Bachelor Business administration; advanced knowledge of Mathematics, Statistics and Operations Research

**Content:**
The course covers decision-oriented aspects of SCM and discusses basic concepts, models, and methods for hierarchical planning in supply chains.This course content provides the foundation for a critical examination of planning systems from a theoretical and practical perspective. This builds the foundation to study case studies and papers with respect to sustainability.

**Intended Learning Outcomes:**
The students:
- know the conceptual structure of supply chain planning and understand basic concepts, models, and methods that are applied in supply chain management
- gain experience in the supply chain management using prevalent software systems and understand scope and limitations in supporting practical decision situations.
- hone their skills with respect to modeling and solving decision problems in sustainable supply chain management.

**Teaching and Learning Methods:**
Lecture (theory), tutorials with group work and presentation

**Media:**
Seminaristic tution using beamer, overhead projector, flipchart

**Reading List:**
Stadtler/Kilger/Meyr (2015): Supply Chain Management and Advanced Planning. Concepts, Models, Software, and Case Studies. 4. Aufl., Springer (Berlin).
Cachon/Terwiesch (2012): Matching Supply with Demand
Chopra/Meindl (2009): Supply Chain Management: Strategy, Planning, and Operation, Global Edition

**Responsible for Module:**
Alexander Hübner alexander.huebner@tum.de

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

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

## Module Description

### CS0174: Marketing for Biobased Products | Marketing for Biobased Products [MBBP]

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
The exam will be in form of an oral exam. By answering questions students have to show that they have understood and can apply the thaught specific principles of the marketing of bio-based products and industrial marketing. No additional tools are allowed during oral examination with a duration of 15 minutes. In a students' project, the students demonstrate the scientific analysis and possible solutions of specific questions related to a defined topic concerning the marketing of biobased products including industrial marketing. The results of the project work will be presented (20 min; passed/non-passed) by the students with subsequent discussion with the other students and the lecturers.
In this students' project, the students demonstrate understanding of specific questions related to a defined topic concerning the marketing of bio-based products and services. Students have to show in their presentation that they can analyse, solve and answer defined problems and questions related to this topic. Participants of the course show that they have done appropriate research work and are able to present their results. By answering follow-up questions related to their presentation they show that they have learned to put their research outcome into the relevant product and market context.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basic know-how related to marketing and markets of biobased products is recommended

**Content:**
The content of the module comprises in one part specific aspects of the marketing of biobased products and services. This part includes in particular the modification of methods and instruments of strategic marketing to this specific group of products and services (e.g. holistic character

of change in raw material basis, use of by-products and cycle approaches), the particular target groups of such products and their behavior (e.g. characteristics of related target groups, attitude-behaviour gaps), adaptations in the marketing-mix (e.g. specific benefits, labelling and identification of biobased products, avoidance of greenwashing, biomass logistics) as well as specific aspects related to the marketing of sustainability-oriented products and services (e.g. sustainable consumption and its barriers, sustainability evaluation and standards, Fair trade). Industrial marketing will be thaught in a second part of the module with a focus on specific tasks of industrial marketing, characteristics of different transaction types, specific features of transactions and service offers in the business-to-business area, as well as the combination of value chains, customer integration and service offers. Additionally, the procurement of business and state organisations will be considered with a focus on uncertainty and information as important factors in the buying process as well as concepts to analysing a buying center.
Besides, the students will use the taught methods and tools in a students' project in which actual questions and case studies related to the marketing of biobased products and services under consideration of industrial marketing will be analysed and answered.

**Intended Learning Outcomes:**
After attending the module, students will be able to use the instruments and methods of strategic and operational marketing related to biobased products and services thereby considering the specific aspects of industrial marketing in this context. They can deflect specific target groups for biobased products and services, analyse their behavior and derive targeted marketing strategies and their operationalization. Additionally, students can analyse the specific characteristics and challenges of sustainability-oriented products and services and are able to assess these in form of adapted marketing strategies and concepts. Students can evaluate the principles and specific tools of industrial marketing and can use these in the field of biobased products and services. Besides, students can distinguish important theoretical and practical approaches related to the procurement of business or state organisations and rate those with the specific characteristics of biobased products and services.

**Teaching and Learning Methods:**
The lecture will be done using Powerpoint with specifically worked out presentation scripts. In addition, published studies, scientific papers and statistical data will be integrated into the lectures. In the students' project, students use the taught methods and instruments of the marketing of biobased products and services, industrial marketing as well as their factual knowledge to analyse actual questions and cast studies related to the application fields of biobased products and services and derive adapted marketing strategies and concepts. They will present and discuss their approach and solutions with their colleagues and the lecturers.

**Media:**
Presentation slides, actual literature and studies, online discussion forum (all lecture materials are available via Moodle)

**Reading List:**
Specific literature and documents will be provided to the topics of the lectures as well as the topics that are worked on in the student projects

**Responsible for Module:**
Menrad, Klaus; Prof. Dr.sc.agr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Specific aspects of the marketing of biobased products (Vorlesung, 1 SWS)
Menrad K [L], Menrad K

Applied marketing for biobased products (Projekt, 2 SWS)
Menrad K [L], Menrad K, Stelzl B

Industrial marketing (Vorlesung, 1 SWS)
Menrad K [L], Stelzl B
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0226: Corporate Strategy | Corporate Strategy

Version of module description: Gültig ab winterterm 2022/23

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

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

**Description of Examination Method:**
Group Project and Group Presentations: 60%; Online Exam (60 min.): 40%

**Repeat Examination:**

**(Recommended) Prerequisites:**
Basic knowledge of business administration

**Content:**
Students are introduced into the topic of corporate strategy based on a thorough understanding of what strategy means in the context of corporate management. Further, students learn about key management analysis tools and whose application to real life scenarios by the means of case studies. Subsequently, corporate strategy is looked at from a regional, national and international perspective including the notion of innovation and the formation of competitive advantage.

**Intended Learning Outcomes:**
The students obtain knowledge in
• gaining a broad understanding about core themes of corporate strategy, related processes and theoretical underpinnings,
• understanding strategic analysis tools in the context of case studies and further examples
• developing a critical understanding of strategy in the context of corporate management with the objective to improve strategic decision making, and
• obtaining the ability to develop managerial reports based on the above.

The student enhance their skills in
• evaluating presented information in a critical manner based on the information presented in the course,

• applying strategic analysis tools and interpret the results of such analysis,
• presenting the results of his/her work in a concise way to a larger audience, and
• connecting local/regional/national corporate strategy topics to an international context.

The student obtain further general qualifications in
• having insights into relevant topics and issues in the context of corporate strategy,
• applying relevant theoretical frame works to case studies and demonstrate an in-depth understanding of the results,
• planning and executing relevant project work in a timely fashion in the context of a group project,
• presenting and contextualizing relevant information, theories and issues of the corporate strategy domain (oral and written),
• discussing relevant information and topics with peers as part of the course, and
• connecting the concept of innovation to corporate strategy and business success

**Teaching and Learning Methods:**
The basic concepts are presented with slide-based lectures. The models and methods are presented and illustrated by means of exercise examples, including practical applications in corporate strategy management. These contents form the basis for a critical consideration from a theoretical-conceptual and practical-application-oriented point of view. Current research papers, case studies and textbooks are used as the basis for this.

**Media:**
Core text book, case studies, academic journal articles, lecture slides, relevant online content

**Reading List:**
Exploring Strategy by Johnson, Whittington and Scholes

**Responsible for Module:**
Prof. Alexander Hübner

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

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

# Module Description

## CS0227: LCA Case Studies | LCA Case Studies [LCA CS]

Version of module description: Gültig ab summerterm 2022

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
Written group assignment and oral group presentation: Students are training their skills in Life Cycle Assessment by carrying out and report a small LCA study including data collection. Students are free to use the openLCA software for modelling. Performing the calculations with spread-sheets is also fully accepted.

In groups of at least two persons, students identify and select a topic for their LCA case study. Each group has to perform all four phases of an LCA. This consists of
- Writing a goal and scope definition,
- Collecting data for carrying out the inventory analysis,
- Selecting suitable life cycle impact categories and performing a life cycle impact assessment,
- Interpreting the results, discussing the own study including its limitations by comparing it with other LCA studies/reports in the same/similar topic.
- Presenting the results in form of a presentation and a written report

The examination consists of three parts. The weighting is as follows:
(1) Goal and scope definition (20%)
(2) Final presentation (30%)
(3) Final report (50%)

In the Goal and Scope Definition (~5 pages), the topic and purpose of the LCA case study is established and decisions are made about the product system being studies. In drafting the goal and scope definition, students show that they are able to identify and select an object for analysis, to structure a problem and plan the outset and further steps of their study.

In the final group presentation (25'), students present their results and have to show that they are able to summarize their findings in a scientific presentation, discuss and defend them (15' for presentation, 10' for discussion).

In the final report (15-20 pages), the students show that they are able to perform a simple LCA case study. Moreover, they proof their study design in a transparent and logical way. By presenting the results of the LCA case study as well as discussing the findings and limitations, students proof their ability to find relevant literature, carry out a small LCA study and document the results of the process in a scientific paper.

**Repeat Examination:**

**(Recommended) Prerequisites:**
The contents of the module Advanced Sustainability and Life Cycle Assessment is required. It can be obtained in parallel to this seminar.

**Content:**
The module contains units covering the following topics:
• Systems and life cycle thinking
• Life Cycle Assessment
• Goal and Scope Definition to plan the outline of the LCA study
• Life Cycle Inventory for data collection and reconciliation
• Life Cycle Impact Assessment to assess the potential environmental impacts
• Handling of data uncertainty
• Literature research and current trends and developments
• Software systems and databases for life cycle assessment
• Case studies

**Intended Learning Outcomes:**
The students use the concepts and tools of life cycle assessment. The goal is to be able to analyse industrial metabolisms as well as products and services regarding their environmental impacts. Thus, students gain a deeper understanding of the LCA methodology and procedure by applying the theoretical knowledge to a practical example.
At the end of the module students are able to carry out an own LCA. This involves carrying out the four phases of an LCA study
• the goal and scope definition phase: to identify and select a suitable product or service system to carry out an LCA case study, explain the key aspects of the goal and scope definition and their relevance for the subsequent LCA phases, to define a functional unit and reference flow for the LCA case
• the inventory analysis phase: to collect the input/output data with regard to the system being studied.
• the impact assessment phase: to address the environmental aspects and potential environmental impacts throughout the life cycle of a product or a service system.
• the interpretation phase: the results of the life cycle inventory and life cycle impact assessment are summarized and discussed as a basis for conclusions, recommendations and decision-making in accordance with the goal and scope definition.

Applying LCA methodology can support further development and improvement of systems, products, and services. This can support decision-making processes, marketing and product/ service improvement in the context of various stakeholders.

**Teaching and Learning Methods:**
Seminar: In parallel to the lecture "Advanced Sustainability and Life Cycle Assessment", this seminar format provides the opportunity to apply the theoretical knowledge of LCA by applying it to a small LCA case study and gaining a deeper understanding of the LCA methodology. After an introduction to the topic, the students identify a product/service system to analyse, carry out a full LCA (incl. data collection, literature research). They receive intermediate feedback to a Goal and Scope Definition of their study. In a next step they carry out a full LCA. In this process they are supervised, receive materials, thematic input, advice in scientific work and continuous feedback in the seminar sessions. The seminar closes with a final presentation.

Teaching / learning methods:
• Kick-off meeting
• Media-assisted presentations
• Video-based tutorials for methodology (e.g. LCA software)
• Individual work and feedback consultations
• Group work / case studies with presentation
• Interim presentations / workshops
• Final group presentations
• Group assignments

**Media:**
Digital projector, board, flipchart, online contents, videos, case studies, LCA software, presentations

**Reading List:**
Recommended reading:
• Curran, M.A. (2015): Life Cycle Assessment Student Handbook, Scrivener Publishing.
• Fröhling, M.; Hiete, M. (2020): Sustainability and Life Cycle Assessment in Industrial Biotechnology. Springer, Cham.
• Guinée, J.B. (2002): Handbook on life cycle assessment: operational guide to the ISO standards. Kluwer, Dordrecht.
• Hauschild, M.Z. & Huijbregts, M.A.J. (2015): Life Cycle Impact Assessment (LCA Compendium - The Complete World of Life Cycle Assessment), Springer, Cham.
• Hauschild, M.; Rosenbaum, R.K.; Olsen, S.I. (2018): Life Cycle Assessment: Theory and Practice. Springer, Cham.
• Jolliet, O., Saade-Sbeih, M. (2015): Environmental Life Cycle Assessment. CRC Press.
• Klöpffer, W. & Grahl, B. (2014): Life Cycle Assessment (LCA), Wiley-VCH.

**Responsible for Module:**
Fröhling, Magnus; Prof. Dr. rer. pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
LCA Case Studies (Seminar, 3 SWS)
Fröhling M [L], Schirmeister J, Corella Puertas M
For further information in this module, please click campus.tum.de or here.

## Module Description

# CS0228: Technology and Management of Renewable Energies in a Global Context | Technology and Management of Renewable Energies in a Global Context [REAE]

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
The exam will be in form of an oral presentation of the students (20+10 minutes;  75% of the grade) and a short report of the students' project work (max. 5 pages, not counting front page and cited literature; 25% of the grade).

In this students' project, the students demonstrate understanding of specific questions related to a defined topic concerning the technology and management of renewable energies in a global context. Students have to show in their presentation that they can analyse, solve and answer defined problems and questions related to this topic. Participants of the course show that they have done appropriate research work and are able to present their results. By answering follow-up questions related to their presentation they show that they have learned to put their research outcome into the relevant technical or country context. The presentation slides and the short report will be handed over to the lecturers and will be included in the grading.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basic know-how related to specific techniques of renewable energies (e.g. solar energy, wind energy, hydropower, biomass conversion technology, geothermal energy) as well as management of energy systems either on a company or on state level.

**Content:**
A) Technical aspects of different forms of renewable energies (e.g. current state of technology, technical options for the future, technical bottlenecks, scale-up possibilities)
- Wind power

- Hydropower
- Photovoltaics, solarpower
- Geothermal energy
- Biomass use for energy purposes
- Biofuels, electric vehicles, E-fuels
- Hydrogen
- Other forms of renewable energies

B) Economic aspects related to defined renewable energies (e.g. cost of use/production, cost structure and development in the past, learning curves, innovation and diffusion of renewable energies)
C) Influencing factors for adoption and use of renewable energies (e.g. natural/local conditions, availability of renewable resources, technical infrastructure, user structure of energy, cost and economic factors, financing, political and regulatory issues, social acceptance, behaviour of stakeholders and people)
D) Situation and development in a specific (country) context (e.g. governance, policy goals and activities, competing factors and interests (e.g. by fossil energy use or related companies/ stakeholders), legal and regulatory stability)

**Intended Learning Outcomes:**
At the end of the module, students will be able to analyse and elaborate solutions for existing problems related to the technology and management of renewable energies and apply such solutions to the specific context of selected countries worldwide. They consider both the technical side as well as the economic and management dimension in order to develop integrated solutions for a specific question related to renewable energies. Additionally they take the specific context and situation (e.g. technical infrastructure and know-how, maintenance, electrical or other grids, political and regulatory rules, economic framework, company and user structure) in one or several countries or regions into account when analysing and elaborating solutions for the question on-hand. They are able to apply their knowledge to create an oral presentation and a written summary of their findings. Presented results are discussed with the audience so that students are able to defend their solution and put it in an appropriate context.

**Teaching and Learning Methods:**
The module is a seminar, where course participants form (preferably international) teams that investigate a given topic by autonomously doing research work and discussing results within the team. During regular meetings with the lecturers questions can be discussed, next steps are defined and (interim) results are presented. Lecturers will provide basic and background material for the students as well as actual information for the given topics that are elaborated by the student teams.

Learning activities: Literature/document research, student group project

**Media:**
Presentation slides, online discussion forum (all lecture materials are available via Moodle)

**Reading List:**
Specific literature and documents will be provided to the topics that are worked on in the student projects

**Responsible for Module:**
Menrad, Klaus; Prof. Dr.sc.agr.

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

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

## Module Description

# CS0238: Environmental Behavior and Support for Climate Policies | Environmental Behavior and Support for Climate Policies

Version of module description: Gültig ab winterterm 2021/22

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

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

**Description of Examination Method:**
Achievement of desired learning objectives shall be verified in a term paper (max. 10 pages) and an oral presentation in a group. The students will implement their own online survey and present the findings in the context of the relevant literature in a group presentation (each student has to present 10 minutes). The oral presentation shall be assessed according to content and rhetoric aspects. The term paper is written individually and summarizes the relevant literature, empirical method, data, and key findings. Weighting: Term paper 2, Presentation 1.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
The successful transition from a fossil fuel economy to a more bio-based and sustainable circular economy requires pro-environmental behavior and public support for long-term climate policies (e.g., climate neutrality by 2050). This course aims to explain the factors of environmental behavior and why citizens support or reject climate change polices. Based on recent empirical findings from psychology and economics, the following factors influencing behavior and policy support are discussed:

- socio-psychological factors and climate change perception (e.g., political orientation, environmental values, risk perception, emotions, etc.),
- the perception of climate policy and design (e.g., perceived costs, perceived fairness, perceived effectiveness, etc.), and
- contextual factors (e.g., social norms, participations, economic and geographical aspects).

The course consists of a lecture that gives an overview of the factors that influence environmental behavior and public support for climate policies. It will also review methodological questions relevant for (online) surveys. In the integrated exercises students will be trained to implement online surveys and experiments. Students will be assigned to groups and conduct their own online survey and investigate factors that influence pro-environmental behavior and the support for climate policies.

**Intended Learning Outcomes:**
After attending the module, students will understand current topics in the psychology and economics of climate change. They are capable of applying online surveys to analyze the support or rejection towards climate policies and they can reference the relevant empirical evidence. Students can analyze the collected data with the appropriate statistical models. Students learn how to present scientific results in the public. In addition, students learn to write a term paper according to scientific standards.

**Teaching and Learning Methods:**
The lecture will be mostly done by presentations. In addition, articles from newspapers and journals are integrated into the lectures. Together with the lecturer, students will study the content and methods of the academic papers. In the exercises, the students themselves conduct an online survey and analyze the collected data. The results of the online survey are then presented and discussed individually and / or in groups from different perspectives by the students. Students will reproduce what has been learned in a written work.

**Media:**
Presentations, Articles

**Reading List:**
Drews, S., & Van den Bergh, J. C. (2016). What explains public support for climate policies? A review of empirical and experimental studies. Climate policy, 16(7), 855-876.
Bergquist, M., Nilsson, A., Harring, N., & Jagers, S. C. (2022). Meta-analyses of fifteen determinants of public opinion about climate change taxes and laws. Nature Climate Change, 12(3), 235-240.

**Responsible for Module:**
Pondorfer, Andreas; Prof. Dr.sc.pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Environmental Behavior and Support for Climate Policies (Vorlesung mit integrierten Übungen, 4 SWS)
Pondorfer A [L], Pondorfer A, Hoch G
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0239: Advanced Seminar in Environmental and Development Economics | Advanced Seminar in Environmental and Development Economics

Version of module description: Gültig ab winterterm 2024/25

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The examination consists of a written seminar paper proving the ability of writing a scientific paper in the context of environmental and development economics and an oral presentation with discussion. The paper includes individual data analysis using econometric models as well as the discussion of the results and methods used. The seminar paper should cover 15-20 pages and is written in the style of a peer reviewed journal article. At the end of the module students present their work in a 30 minutes presentation. Weighting: Seminar paper 2, Presentation 1

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Advanced Development Economics, Advanced Environmental Economics, Advanced Empirical Research Methods

**Content:**
This advanced seminar focuses on recent developments in environmental and development economics. After being introduced to adequate research themes, students explore the academic literature on a chosen topic and develop their own research question. The topics are typically related to the assessment of interventions regarding determinants and causal relationships theoretically and empirically. Potential topics are:
- entrepreneurship
- agriculture
- migration - Environmental impacts of economic actions

**Intended Learning Outcomes:**
The objective of the module is to equip the participants with the necessary skill and tools for a successful master thesis project in the field of environmental and development economics.

**Teaching and Learning Methods:**
In an introductory session, the theme of the seminar is introduced and elaborated in detail. The introduction will also introduce the relevant literature in environmental and development economics. Based on the introduction, students will develop their own research question and decide on the adequate research methods. During the term students have to reach different milestones (e.g., choose a topic, choose a research method, collect data, outline their paper, write the paper, present the results) on specific dates. Following the submission of the seminar paper, students will present and discuss their research question and findings. During all stages of the seminar students will be assisted by the lecturer(s).

**Media:**
Research papers; presentation slides

**Reading List:**
Valerie Matarese (2013). Using strategic, critical reading of research papers to teach scientific writing: the reading–research–writing continuum, Editor(s): Valerie Matarese (2013). In Chandos Information Professional Series, Supporting Research Writing, Chandos Publishing,Pages 73-89. https://doi.org/10.1016/B978-1-84334-666-1.50005-9.)

Yongyan Li, Margaret Cargill, Xin Gao, Xiaoqing Wang, Patrick O'Connor (2019). A scientist in interdisciplinary team-teaching in an English for Research Publication Purposes classroom: Beyond a “cameo role”,
Journal of English for Academic Purposes, Volume 40, Pages 129-140. https://doi.org/10.1016/j.jeap.2019.06.005.

Yongyan Li, John Flowerdew (2020). Teaching English for Research Publication Purposes (ERPP): A review of language teachers’ pedagogical initiatives, English for Specific Purposes, Volume 59, Pages 29-41. https://doi.org/10.1016/j.esp.2020.03.002.

**Responsible for Module:**
Faße, Anja; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Seminar in Environmental and Development Economics (Seminar, 4 SWS)
Faße A [L], Faße A
For further information in this module, please click campus.tum.de or here.

## Module Description

### CS0241: Excursion Circular Economy & Sustainability | Excursion Circular Economy & Sustainability

Version of module description: Gültig ab summerterm 2023

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>irregularly |
| **Credits:***<br>3 | **Total Hours:** | **Self-study Hours:** | **Contact Hours:** |

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

**Description of Examination Method:**
Passed/not passed: Participation in total excursion; 10-15 min preparatory keynote; 1-2 written pages reflection after excursion

**Repeat Examination:**

**(Recommended) Prerequisites:**
Participation in the excursion is linked to registration and participation in the "Advanced Seminar in Circular Economy and Sustainability Management" or to use the research results of the excursion in a Master Thesis (to be discussed prior with the module responsible)

**Content:**
12-day excursion to Ghana to carry out the necessary scientific works for the seminar or the master thesis with student keynotes on cultural topics as preparation and written reflection after arrival. Visiting hot spots of ecological challenges and stakeholders actively contributing towards more sustainable behavior. Engaging with locals for on-site research.

**Intended Learning Outcomes:**
The excursion aims to support the profile building and the acquisition of scientific and social competencies. The main focus is to create and gain first-hand insights on Circular Economy topics in Ghana and to counteract the habit of talking from a Northern perspective about the challenges of the Global South. By participating in the excursion, students should be enabled to acquire in-depth knowledge on the seminar topics offered within the "Circular Economy in the Global South, the case of Ghana" on-site and firsthand.
The students will get insights into the diverse and rich Ghanaian culture, which will further enhance their understanding of global Circular Economy challenges.

By performing on-site field research to collect primary data, they will develop solution approaches to closing resource loops and establish contact with locals.

**Teaching and Learning Methods:**
Excursion: after a kick-off session and several introductory lectures, the students will carry out literature research on cultural and travel-relevant aspects related to Ghana. They summarize their findings in an oral keynote. In this process, they are supervised, receive materials, thematic introductions, and continuous feedback. After returning from the excursion, they will reflect upon their learnings in written form.

Teaching/learning methods:
- Kick-off session
- Lectures
- Individual work and feedback
- Presentation
- On-site visits
- Workshops
- Exchange with locals

**Media:**
Digital projector, board, flipchart, online contents, recent scientific journal publications

**Reading List:**
Topic related reading, especially articles in international peer reviewed journals, will be provided in the kick-off meeting and lectures of the module.

**Responsible for Module:**
Magnus Fröhling

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

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

# Module Description

## CS0244: Inventory and Transportation Management | Inventory and Transportation Management

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Written exam: 60 minutes written exam on presentation, recommended readings, and case studies

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Bachelor Business administration; advanced knowledge of Mathematics, Statistics and Operations Research

**Content:**
The course covers decision-oriented aspects of logistics and discusses basic concepts, models, and methods for inventory management and transportation planning in supply chains. This course content provides the foundation for a critical examination of logistics systems from a theoretical and practical perspective.

Part A: Introduction
▪ Terminological Issues of Logistics Management
▪ Principles of Logistics Management

Part B: Inventory Management
▪ Basics of Inventory Management
▪ Lot Sizing
▪ Safety Stock
▪ Work-in-Process

Part C: Transportation Management

▪ Basic Methods for Transport Optimization
▪ Transportation Planning
▪ Packaging
▪ Shortest Rout Problems
▪ Traveling Salesman and Vehicle Routing

**Intended Learning Outcomes:**
The students:
- know the conceptual structure of inventory management and transportation planning and understand basic concepts, models, and methods that are applied in industry and logistics applications
- gain experience in the logistics using prevalent decision models, software systems and understand scope and limitations in supporting practical decision situations.
- hone their skills with respect to modeling and solving decision problems in logistics management.

**Teaching and Learning Methods:**
Lecture (theory), tutorials with group work and presentation

**Media:**
Seminaristic delivery using beamer, overhead projector, flipchart

**Reading List:**
Chopra/Meindl (2009): Supply Chain Management: Strategy, Planning, and Operation, Global Edition
Ghiani, G., Laporte, G., Musmanno R. (2013), Introduction to Logistics Systems Management, 2. edition, Wiley
Günther, H.O., Tempelmeier, H. (2020), Supply Chain Analytics
Silver, E. A., Pyke, D. F. und R. Peterson, Inventory Management and Production Planning and Scheduling, 3. edition, New York (Wiley) 1998.

**Responsible for Module:**
Alexander Hübner

**Courses (Type of course, Weekly hours per semester), Instructor:**
Inventory and Transportation Management (Lecture) (Vorlesung, 2 SWS)
Hübner A [L], Hübner A

Inventory and Transportation Management (Exercise) (Übung, 2 SWS)
Hübner A [L], Riesenegger L
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0274: Economic History and Comparative Development | Economic History and Comparative Development

*The roots of wealth and inequality across the globe*

Version of module description: Gültig ab winterterm 2022/23

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

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

**Description of Examination Method:**
Achievement of desired learning objectives shall be verified in a term paper (max. 10 pages) and an oral presentation in a group. The students will provide an overview of their chosen topic and present the findings in the context of the relevant literature in a group presentation (each student has to present 10 minutes). The oral presentation shall be assessed according to content and rhetoric aspects. The term paper is written individually and summarizes the relevant literature, empirical method, data, and key findings. Weighting: Term paper 2, Presentation 1.

**Repeat Examination:**

**(Recommended) Prerequisites:**
Advanced Development Economics

**Content:**
Why, when and how did the world become rich/poor? Research of contemporary economic development has often neglected historical factors in explaining differences in inequality and wealth. The study of the past was usually delegated to the field of economic history, and connections between historical factors and present-day economic outcomes were seldom made. This course will cover the rapidly growing body of research within economics that takes a historical perspective into account.

The course uses a historical and comparative approach to understand the evolution and development of societies. In particular, we will examine research that asks whether differences in economic development, wealth and inequality today have historical roots. In addition, we will study different mechanisms and channels through which history matters. Particular attention will be paid to the role of institutions, geography and culture in explaining historical persistence. The course also covers important empirical methods to identify the causal effects of past historical events (e.g., the different types of colonial institutions) on current outcomes (e.g., GDP per capita in 2010).

While the material covered in the course is grounded in the field of economic history, there is a natural overlap with other fields in economics, particularly development economics, political economy, and cultural economics, as well as overlap with other disciplines, such as history, psychology, political science, anthropology, archaeology, and geography.

**Intended Learning Outcomes:**
After attending the module, students will understand what historical factors influenced economic development and how persistent these factors are, i.e., how they still affect economic outcomes across countries today. Students can apply theories, concepts, and analytical techniques associated with economic history and microeconomics. Students will be also capable of using empirical methods to analyze persistent effects of historical data. In addition, students will learn to present scientific results and write a term paper according to scientific standards.

**Teaching and Learning Methods:**
The lecture will be mostly done by presentations (PowerPoint). In addition, articles from newspapers and journals are integrated into the lectures. Together with the lecturer, students will study the content and methods of the academic papers. In the exercises, the students themselves choose a topic related to economic history and comparative development. The findings of their analysis will be presented and discussed individually and / or in groups from different perspectives by the students. Students will reproduce what has been learned in a written work (term paper).

**Media:**
Presentations, articles

**Reading List:**
- Oded Galor (2022), The Journey of Humanity. Random House.
- Joseph Henrich (2020), The Weirdest People in the World. Penguin Random House.
- Alberto Bisin and Giovanni Federico (2021), The Handbook of Historical Economics, Academic Press
- Bibliography of scientific publications

**Responsible for Module:**
Pondorfer, Andreas; Prof. Dr.sc.pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Economic History and Comparative Development (Vorlesung mit integrierten Übungen, 4 SWS)
Pondorfer A [L], Pondorfer A, Ahmed M
For further information in this module, please click campus.tum.de or here.

## Module Description

### CS0275: Economic Valuation of Consumer and Environmental (non-market) Goods | Economic Valuation of Consumer and Environmental (non-market) Goods

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
The examination will be given in the form of a written examination as well as students' presentations.
The students should be able to evaluate and use the taught methods of market analysis. Using case studies, students must discuss various questions related to the theoretical background of non market goods and consumer goods. Besides that, the students have to answer questions about the used statistical programs and data analysis. Duration of written examination: 60 minutes. The proportion of the written examination is 50% of the total grade.

The students' presentations aims to present the scientific methods and results of a student project elaborated during the semester. The students present individually or in groups the elaborated results and discuss them with their colleagues and lecturers. Powerpoint and presentation equipment are allowed for the presentations. Students must give an intermediate presentation (duration: 10 minutes) and a final presentation (duration: 20 minutes). Students will only be admitted to the final presentation if they have successfully completed the interim presentation. The proportion of the presentations is 50% of the total grade.

Both parts of the grade (written examination and presentation) must be passed in order to successfully complete the module.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Prerequisites for the successful participation is knowledge about,
- basic knowledge about non-market goods

- basics of multivariate analysis methods
-basics in empirical data collection

**Content:**
This course aims to explain the valuation of consumer goods and non-market goods.

In the first part of the lecture, students will learn basic aspects of consumer goods and of environmental goods.
Consumer goods: The students get to know different types of consumer goods (e.g. durable goods, nondurable goods, services) and how they can be characterized.
Non-market goods: These goods provide many services, like clean air, carbon capturing or protection against floods or erosion. These ecosystem services are not traded on a market and accordingly do not have an observable market price. To show the value of environmental services, e.g. to evaluate policy measures that enhance or reduce ecosystem services, we need approaches for nevertheless quantifying the value of environmental services.

Based on the first part, the second part of the course introduces and discusses different methods for (non-) market valuation of consumer goods and environmental services. Students will learn the theoretical background of a Choice Based Conjoint Analysis as well as its application by means of examples. The analysis of sample data will also be discussed and practiced with the help of appropriate software (e.g. Sawthooth).

In the third part of the module, students have to apply the methods and tools they have learned. The students receive already collected data (in the field of consumer goods) or implement their own online survey using a Choice Based Conjoint approach (in the field of non-market goods). Students have to develop specific research questions based on the given data or non-market good scenario using also information provided in scientific literature. After that, students must analyze data using a Choice-Based Conjoint analysis to answer their research questions. In a final step, students must present their findings.

**Intended Learning Outcomes:**
After attending the module, students can characterize current topics and methods in the evaluation of consumer and environmental (non-market) goods. Students will learn to analyze and use different concepts for valuing consumer goods and environmental services as well as the concepts' strengths and weaknesses. Further, they will learn how to collect, analyze, and evaluate data by using choice analytics survey software as well as to interpret the results.

**Teaching and Learning Methods:**
The lecture will be mostly done by presentations. In addition, articles from newspapers and journals are integrated into the lectures. Together with the lecturer, students will study the content and methods of the academic papers.
In the project work, the students themselves either analyze collected data (which will be provided to the students) or implement an online survey for non-market goods and analyze the data

collected in this survey. The results of the evaluation are then presented and discussed individually and / or in groups from different perspectives by the students.

**Media:**
Presentations, slide scripts, articles

**Reading List:**
- Sawthooth manuels
- Hair, J.F., Black, W.D., Babin, B.J., & Anderson, R.E. (2013): Multivariate Data Analysis, Pearson, Upper Saddle River
- Champ, P.A., Boyle, K. J., and & Brown T. C., (2017): A Primer on Nonmarket Valuation, Springer

**Responsible for Module:**
Thomas Decker (thomas.anton.decker@mytum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**
Economic Valuation of Consumer and Environmental (non-market) Goods (Vorlesung mit integrierten Übungen, 4 SWS)
Pondorfer A [L], Pondorfer A, Decker T
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0277: Sustainability and Risk Management | Sustainability and Risk Management

Version of module description: Gültig ab winterterm 2022/23

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

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

**Description of Examination Method:**
Achievement of desired learning objectives shall be verified in a term paper (max. 15 pages) and an oral presentation in a group. The students will provide an overview of their chosen topic and present the findings in the context of the relevant literature in a group presentation (each student has to present 10 minutes). The oral presentation shall be assessed according to content and rhetoric aspects. The term paper is written individually and summarizes the relevant literature, empirical method, data, and key findings. Weighting: Term paper 2, Presentation 1.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
In the light of recent studies on climate change, economies face major challenges in achieving climate targets and halting global warming. Nowadays climate risks are a central challenge for the real and financial sector, which is why all companies and financial intermediaries must take climate risks into account in their risk management. The European Union sees the reorientation of the financial industry towards sustainable finance as a central bridge to the implementation of the Paris climate targets. In view of these challenges and in order to mitigate ESG (Environment, Social and Governance) risks, including climate risks, this course will examine the way in which business and society make an assessment of, control and transfer risks.
This course will provide an understanding and application of quantitative and qualitative methods of analyzing and managing risk within organizations. In addition, we will study different multiple risk management tools to make high quality decisions for balancing corporate risk and reward tradeoffs.

Financial risk topics will include the examination of derivative application uses for hedging risk, measuring Value at Risk and exploring external impacts such as market, credit and systemic risks.
Enterprise risk topics will include constructing frameworks for managing strategic, operational and outsourcing of business risks. We will examine ways to assess and measure risk along with organizing corporate governance policies.

**Intended Learning Outcomes:**
After attending the module, students will be prepared to function in a business environment, developing an awareness of the challenges, the tools, and the process of designing and implementing a sustainability and risk management program. Students can apply theories, concepts, and analytical techniques associated with sustainability and risk management. Students will be also capable of using empirical methods to analyze and evaluate risks. Moreover, students will develop the ability to identify strengths and weaknesses of approaches to solutions from fact-based analysis and to synthesise them creatively into improved solutions. In addition, students will learn to present scientific results and write a term paper according to scientific standards.

**Teaching and Learning Methods:**
The lecture will be mostly done by presentations (PowerPoint). In addition, articles from newspapers and journals are integrated into the lectures. Together with the lecturer, students will study the content and methods of the academic papers. In the exercises, the students themselves choose a topic related to sustainability and risk management. The findings of their analysis will be presented and discussed individually and / or in groups from different perspectives by the students. Students will reproduce what has been learned in a written work (term paper).

**Media:**

**Reading List:**
• Gardoni (Ed.) (2017). Risk and Reliability Analysis: Theory and Applications. Springer International Publishing.
• Tamas Vasvari (2015). Risk, Risk perception, risk management – a Rewiew of the Literature. Pablic finance Quarterly. State Audit Office of Hungary, vol. 60(1).
• A Risk Practitioners Guide to ISO 31000: 2018. (2018). Review of the 2018 version of the ISO 31000 risk management guidelines and commentary on the use of this standard by risk professionals. Institute of Risk Management. A company limited by guarantee. Registered in England number 2009507
• Borghesi A., Gaudenzi, B. (2013). Risk Management, Perspectives in Business Culture, Springer-Verlag Italia
• Peter Moles (2016). Management Sources of Financial Risk and Risk Assessment. Edinburgh Business School Heriot-Watt University Edinburgh
• Bessis,J. (2015) Risk Management in Banking 4th ed. (UK)
• Crouhy M, D Galai and R Mark (2009) Risk Management, New York: McGraw Hill.

• Greuning,H., Bratanovic, S. (2013) Analysing Banking Risks: A Framework for Assessing Corporate Governance and Risk Management, 4th ed. The World Bank
• Mechler, R. et al (eds.) (2019) Loss and Damage from Climate Change : Concepts, Methods and Policy Options, Cham
• Shin, Hyun Song (2019) Risk and Liquidity, Claredon Lectures in Finance
• Selected publications from Basel Committee on Banking Supervision, ESAs, EPCC, WMO.
• Aagaard A. (2019) Sustainable Business Models: Innovation, Implementation and Success. Palgrave Macmillan.
• Leleux, B. & van der Kaaij, J. (2019) Winning sustainability Strategies (Finding Purpose, Driving Innovation and Executing Change). Palgrave Macmillan
• Schoenmaker, D., & Schramade, W. (2019). Principles of Sustainable Finance. New York: Oxford University Press.
• Bielenberg, A., Kerlin, M., Oppenheim, J., & Roberts, M. (2016). Financing change: How to mobilize private sector financing for sustainable infrastructure. Chicago: McKinsey Center for Business and Environment.
• European Political Strategy Centre. (2017). Financing Sustainability, Triggering Investments for the Clean Economy. Brussels: European Commission.
• High-Level Expert Group on Sustainable Finance. (2018). Financing a Sustainable European Economy-Final Report. Brussels: European Commission.
• Filippi M.E. (2022). A role for municipal governments in leveraging transformative change for urban disaster risk management: The experience of Santa Fe, Argentina, with urban flood risk,Climate Risk Management, Volume 35.
• Bo Chen, Liuxin Chu (2022). Decoupling the double jeopardy of climate risk and fiscal risk: A perspective of infrastructure investment, Climate Risk Management, Volume 37
• Henry Ngenyam Bang, Nicholas Church Burton (2021). Contemporary flood risk perceptions in England: Implications for flood risk management foresight, Climate Risk Management, Volume 32

**Responsible for Module:**
Pondorfer, Andreas; Prof. Dr.sc.pol.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Sustainability and Risk Management (Vorlesung mit integrierten Übungen, 4 SWS)
Pondorfer A [L], Shkola V
For further information in this module, please click campus.tum.de or here.

## Module Description

# CS0278: Sustainability and Innovation Management in an Industrial Context | Sustainability and Innovation Management in an Industrial Context

*The transformation of ESG into value and growth*

Version of module description: Gültig ab summerterm 2023

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

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

**Description of Examination Method:**
Lecture: Written exam (90 minutes): Students have to analyse, assess and discuss (simplified) sustainability / ESG-driven innovation frameworks, processes and product case studies on a local, regional, national and global level. They determine starting points for an optimisation of these concepts and apply them to real-life use cases. Thereby, they have to take different points of view. In doing so, the students have to prove their ability to use the right vocabulary, and their knowledge on the motivation and key figures of sustainably innovation.
Seminar: Intermediate and final team presentations: Student teams have to analyse, assess, discuss and select a certain sustainability/ESG-driven idea/proposal they would like to transform into reality step-by-step.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
The module covers the following topics:

• The nature of innovation in its inherent key ingredient: Uncertainty.
• The process of industrial innovation and its various stages
• Tools to manage each stage of the innovation process professionally to reduce uncertainty & risk and improve the performance and results of each stage
• The different levels of industrial innovation and their interdependencies

• The creation and management of innovation portfolios, innovation roadmaps, and innovation projects
• The concept of ESG in sustainability management and various ESG criterions
• Legal and policy frameworks regarding sustainability/ESG such as the European Green Deal
• The impact of sustainability/ESG on performance, shareholder value, and investment decisions
• The introduction of various theoretical frameworks regarding the development of human value systems related to sustainability/ESG
• The introduction and discussion of various broader sustainability/ESG-driven innovation frameworks such as circular economy, sharing economy, sustainable urban mobility, bioeconomy, carbon to value/decarbonization, sustainable energy systems etc.
• Identifying innovation potentials regarding sustainability/ESG inside innovation frameworks, business models, products, systems or components and tools to address these potentials to create value
• The creation and management of sustainability/ESG-related innovation portfolios, road maps and projects
• An interdisciplinary and coached real-life simulation in teams on selected sustainability/ESG-driven innovation ideas/proposals to apply and train the gained knowledge on how to identify promising projects and transform them into successful marketable products.

**Intended Learning Outcomes:**
Students remember and understand the nature and different stages of industrial innovation and they understand how the transformation from ideas to products can be managed professionally through tools such as innovation portfolios, innovation roadmaps and innovation project management. They understand the several levels of innovations and the strong interdependencies between these levels. They can apply their knowledge to analyse, evaluate the composition of any given business model or product (concept) to identify innovation potentials and to create, analyse, propose and prioritize ideas/proposals that would address these innovation potentials in a way that value can be created.
Students remember and understand the legal and policy frameworks related to sustainability/ESG. They understand the concept of ESG in the context of sustainability management, the various sustainability/ESG criterions and their impact on business performance, shareholder value and investments decisions. They gain an understanding into the development of human value systems and understand why sustainability is a key foundation for the next innovation super cycle that will drive economy and development throughout the next decades.
Based on a deep understanding of the nature of innovation and sustainability/ESG students can evaluate and analyse broader ESG-innovation frameworks such as circular economy, sharing economy, bio economy, sustainable urban mobility, sustainable housing, carbon-to-value/decarbonisation etc. and their practical implications.
Students will be able to apply their knowledge and to create and manage ESG-related innovation portfolios, roadmaps and innovation projects inside existing or new organisations such as start-ups

**Teaching and Learning Methods:**
Format: lecture and exercises to introduce the content, to repeat and deepen the understanding as well as practice individually and in groups.

Teaching / learning methods:
- Media-assisted presentations
- Group work / case studies / reading of scientific publications with presentation
- Individual assignments and presentation to consolidate/repeat the learned contents
- Plenary discussions to reflect the lecture contents
- Group work on the transformation sustainability/ESG-driven innovation ideas/proposals
- Design Thinking
- Teams and individual coaching sessions
- Project pitches (Final and intermediary)

**Media:**
Digital projector, board, flipchart, online contents, case studies

**Reading List:**
Recommended reading:

• Hauschildt, Jürgen; Salomo, Sören et al: Innovationsmanagement (2016/2023), Vahlen
• Dodgson, Mark; Gann, David: The Oxford Handbook of Innovation Management (2015), Oxford University Press
• Thewes, Rüdiger: Let´s Change a Running System: Transformationswege in eine Nachhaltige Wirtschaft (2021), Tredition
• Christensen, Clayton: The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail (2016), Harvard Business Review Press
• Allianz Global Investors (2010): The sixth kontratieff – long waves of prosperity: https://www.allianz.com/content/dam/onemarketing/azcom/Allianz_com/migration/media/press/document/other/kondratieff_en.pdf
• Mathews, John A.: Greening of Capitalism: How Asia Is Driving the Next Great Transformation (2014), Stanford University Press
• Nefiodow, Leo: The Sixth Kondratieff: A New Long Wave in the Global Economy (2017), CreateSpace Independent Publishing Platform
• Beck, Don Edward; Cowans, Christopher C. : Spiral Dynamics - Leadership, Werte und Wandel: Eine Landkarte für Business und Gesellschaft im 21. Jahrhundert (2020), Kamphausen Media
• Circularity Gap Report Global (2022); https://www.circularity-gap.world/2022
• Osterwalder, Alexander; Pigneur, Yves: Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers (Strategyzer) (2010), Wiley
• Lewrick, Michael : Design Thinking for Business Growth: How to Design and Scale Business Models and Business Ecosystems (2022), Wiley
• https://www.europarl.europa.eu/news/en/headlines/society/20200618STO81513/green-deal-key-to-a-climate-neutral-and-sustainable-eu
• Deloitte: Fit for 55: Maßnahmenpaket der EU zur Umsetzung des Green Deal (2022), Deloitte
• McKinsey: The green business building opportunity (2022), McKinsey
• Peter Lacy, Jessica Long: The circular Economy Handbook: Realizing the Circular Advantage (2020), Wesley Spindler

• UNITED NATIONS SDGS: https://www.undp.org/sustainable-development-goals?utm_source=EN&utm_medium=GSR&utm_content=US_UNDP_PaidSearch_Brand_English&utm_campaign=C
gIVhuJ3Ch3pVQtFEAAYAyAAEgLnGvD_BwE
• EUROPEAN GREEN DEAL: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en
• Bardi, Ugo: LIMITS TO GROWTH REVISTED (2011), Springer
• Dixson-Decleve Sandrine; Gaffney, Owen, et al.:  EARTH FOR ALL: A Survival Guide for Humanity (2022), New Society Publishers

**Responsible for Module:**
Prof. Magnus Fröhling

**Courses (Type of course, Weekly hours per semester), Instructor:**
Sustainability and Innovation Management in an Industrial Context (Vorlesung, 2 SWS)
Fröhling M [L], Seidel M
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0279: International Markets of Renewable Energies | International Markets of Renewable Energies

Version of module description: Gültig ab summerterm 2023

| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
|---|---|---|---|
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
The examination will be given in the form of a students' presentation. Using case studies of renewable energy applications in selected countries, students must elaborate and discuss relevant topics related to the challenges in the provision of energy. The results must be placed in a country-specific context of the selected renewable energy. The students' presentation aims to present the results of this student project elaborated during the semester. The students present individually or in groups (max. 5 members per group) their research question, methodology and results and discuss them with their colleagues and lecturers. Duration of presentation: 20 minutes. In addition, every student must submit a short, individual elaboration on the topic (5 pages). To successfully pass the module, the student must successfully complete both parts (presentation (50%) and project report (50%)).

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basic knowledge about functioning of (energy) markets

**Content:**
The content of the lecture is structured as follows:
- Global challenges in energy supply and demand
- Political activities to foster the use of renewable energies
- Global markets of fossil fuels
- Global markets for biomass and biogenic by-products
- Worldwide markets for use of renewable energies
- Situation and development of selected (renewable) energy markets in specific countries or regions (projectwork of the students)

**Intended Learning Outcomes:**
After attending the module, students can characterize different energy markets in the world. These markets will be divided into markets for fossile fuels (e.g. crude oil, natural gas, coal), and in markets for regenerative energy production (e.g. wind, hydro, solar energy, biomass, biogenic by-products). Based on this knowledge, the students can classify, analyze and interpret the results found during the individual group work in a country-specific context. Students understand what influences the selected energy markets and why the markets developed as they did.

**Teaching and Learning Methods:**
The lecture will be mostly done by presentations. In addition, articles from newspapers, homepages and journals are integrated into the lectures.
In the seminar, the students must investigate selected (renewable) energy markets of a specific country or region doing a scientific literature review on their own. In the elaboration of their project work, students are supported by several feedback meetings and discussions with the instructor.

**Media:**
Presentations, slide scripts, articles

**Reading List:**
Word energy outlook of the IEA

**Responsible for Module:**
Dr. Decker, Thomas

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

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

## Module Description

# CS0301: Advanced Practical Research Experience | Advanced Practical Research Experience

Version of module description: Gültig ab summerterm 2024

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

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. The student works on a specific problem set. The student runs through several project stages: problem definition, division of work/tasks, decision-making processes, and realization. Throughout this process, the student shows that she/he can develop appropriate strategies to cope with the set of problems. She/he shows the ability able to compose the state of research. In addition, she/he demonstrates the ability to develop their own specific approach for a solution based on scientific knowledge as well as methodical skills.
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:**
Advanced knowledge in concepts of Management and Business Administration
Operations Research (CS0098)
Advanced Modelling and Optimization (CS0170)
Advanced Seminar in Supply and Value Chain Management (CS0112 or CS0090)

**Content:**
The research study consists of a specific problem statement or challenge. This challenge may have a research related or practical character. The research project and its findings regarding the outlined problem set are based on students' academic knowledge gained through their study programs. Examples of topics covered in the context of a include (non-exhaustive list) for example

analyzing potential sales volumes with data mining techniques, identifying potential optimization actions or developing algorithms for certain business problems.

**Intended Learning Outcomes:**
After successful participation in the module, students are able to work on sophisticated research projects in a systematic and academic manner. Students are able to complete a research project in particular in identification research gaps, developing research questions, selecting appropriate research methods and apply them to actual research problem. Students obtain capabilities to deepen and apply theoretical concepts to the identified problem set and develop their analytical solution finding skills. Students become able to manage resources, and deadlines through timely submission of the enumerated tasks in stages throughout their research projects.

**Teaching and Learning Methods:**
The development of the solution of the research question encourages the students to deal soundly with an academic subject based on their previously acquired academic knowledge. The project may happen at the premises of a respective company/institution or from a remote location. Participants are able to communicate the evolvement of the project by composing a project report and preparing a presentation of their solutions to the supervisors. With regards to content, the research study takes an approximate time of 6-8 weeks.

**Media:**
literature, presentations

**Reading List:**
Project Management Institute (2013): A Guide to the Project Management Body of Knowledge (PMBOK® Guide) - Fifth Edition
Further literature based on the specific topic

**Responsible for Module:**
Hübner, Alexander; Prof. Dr. rer. pol.

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

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

# Module Description

## CS0305: Research Excursion Master | Research Excursion Master

Version of module description: Gültig ab summerterm 2024

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>irregularly |
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>60 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
Passed/not passed:
The module is passed when the students deliver a learning portfolio consisting of the following elements::
1. 2 written pages or 20' presentation on preparatory work for the excursion. The form and the due date will be specified in the kick-off session.
2. At least two topical contributions to the excursion (topical input, interviews, questions on presentations and during site visits, discussion contributions;
3. 5-10 PPT slides reflecting the findings based on a case study visited during the excursion. The due date will be specified in the kick-off session;
4. Final report of case studies and results of the workshop;

All four elements of the learning portfolio have to be delivered to pass the module.

**Repeat Examination:**

**(Recommended) Prerequisites:**
Prerequisites may be defined by the professors / lecturers offering the excursion, dependent on the chosen destination / topic. They will be announced with the announcement of the excursion 1 month before the start of lectures in the semester in which the excursion is offered, at the latest.

**Content:**
The research excursion deals with individual topics from modules and / or the study programs for which it is designed. On an individual basis, professors and lecturerers from these modules / study programs offer the research excursion to a topic or place of their choice.

A bullet point list with typically 10-12 entries will be provided by the professors and lecturers with the announcement of the research excursion 1 month before the start of lectures in the semester in which the excursion is offered, at the latest.

After the excursion the results of the applied methodologies are presented and discussed in a workshop. Key findings and the results of the workshop are included in a final excursion report by the students.

**Intended Learning Outcomes:**
The excursion aims to support the scientific profile building of students and the acquisition of scientific, practical and social competencies and the application to case studies visited during the excursion. It supports the competence acquisition in other modules and / or the study programs in general. The students get practical insights into the topical field of the research excursion, deepen their comptencies in this field regarding ongoing research and apply their competencies to real case studies in practice.

In particular, the intended learning outcomes are the following:
- Select relevant scientific and practical information and recall it for for visits of organizations, cities and talks with experts and stakeholders,
- Prepare questions regarding the state-of-knowledge, open research questions and practical relevance and discuss these with fellow students,
- Discuss research and practical knowledge with stakeholders,
- Recognize the implementation of research and practical knowledge in the organisations / sites visited,
- Reflect on the state of implementation of theoretical knowledge in practice,
- Discuss with fellow students and supervisors gained insights and compare it with their expectations,
- Perform structured interviews and talks with experts and stakeholders in practice
- Apply methodologies from theoretical lectures and exercises on practical organizations

**Teaching and Learning Methods:**
The research excursion consists typically of the following elements (teaching, learning and application of methods):
- Kick-off session: To achieve a good get-to-know, brief the students about the module contents, course and required performance an interactive in-presence workshop will be carried out. This covers presentations, and interactive elements such as role games etc.
- Individual work and feedback: In order to prepare for the on-site visits the students carry out own literature research on the excursion topics. To document their learning progress and to be able to share the results they summarize their findings in written form. A presentation of the contents in front of the fellow students is an optional element. In this process, they are supervised, receive materials and continuous feedback.
- On-site visits: 3-5 day research trip with site-visits, presentations, discussions with stakeholders, interviews of experts etc. This part will be specified in the specific program of the research

excursion and can due to the variety of possible destinations and topics not be specified further at this point.
- Individual work: the students will reflect their learnings in written form,
- Workshop: the students will present and discuss their findings in a workshop to gain practical experience for their future working conditions and formulate a final excursion report.

**Media:**
Digital projector, board, flipchart, online contents, recent scientific journal publications, equipment and utilities demonstrating production processes in practice

**Reading List:**
Topic related reading, especially articles in international peer reviewed journals, will be provided during the course of the module.

**Responsible for Module:**
Prof. Cordt Zollfrank Prof. Hubert Röder Prof. Magnus Fröhling

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

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

# Module Description

## CS0315: Business Planning and Valuation | Business Planning and Valuation

Version of module description: Gültig ab winterterm 2024/25

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

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

**Description of Examination Method:**
Achievement of desired learning objectives shall be verified in a written final exam and an oral presetation. In the oral test, the foundations of business analysis and planning are presented by the students based on a case example. In the written examination the students calculate key indicators of business analysis and business plan concepts and evaluate and declare the contents of business plans. This examines whether the students can apply the learned contents of business analysis and planning in their own words. The written final exam shall be integrated into the general assessment by 75% and the oral presentation by 25%.

Type and duration of exam: In writing (60 min) and oral (20 min);

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
none

**Content:**
The "business analysis" lecture includes economic analysis methods based on selected business areas of renewable resources and a case study (e.g. biomass CHP) including the impact of changing business framework.

The "businessplan" exercise provides an introduction to the process of creating a business plan exemplarily by establishing a company. The topics are divided into the following areas:
1. Definition Entrepreneurship
2. Entrepreneurial opportunities and implementation

3. The person of the entrepreneur
4. Innovation and Entrepreurship
5. Business strategy and model
6. Marketing and market orientation
7. Start-up financing
8. Growth and Exit
9. Business Plan

**Intended Learning Outcomes:**
Upon successful completion of this module, the students understand the general framework of business analsyis and planning and are able to understand and apply these methods in practice. Furthermore, students' entrepreneurial thinking is encouraged. In addition, students are able to evaluate existing business plans and to formulate a well structured business plan based on their business ideas.

**Teaching and Learning Methods:**
The module consists of a lecture and an exercise. During the lectures the contents are delivered by presentations and discussions primarily as seminaristic dialogue. The lectures are used to convey the theorectical foundations and include conducting some exercises. The students are inspired to improve the acquired knowledge by studying the suggested literature. In the exercises students apply the acquired knowledge in solving exercises and implementing case studies which also include roll playing. Students deepen their understanding through working in small student groups as well as solving exercises on their own. Team work and role playing supports the training of practical application of the lessons learnt and ability to work in teams.

**Media:**
PowerPoint, script, whiteboard, exercise sheets, reader;

**Reading List:**
KALTSCHMITT, M., STREICHER, W. und A. WIESE (Hrsg.): Erneuerbare Energien. Systemtechnik, Wirtschaftlichkeit, Umweltaspekte. Springer; Auflage: 5. Aufl. 2013.
Quaschnig, V.: Regenerative Energiesysteme: Technologie – Berechnung – Klimaschutz. Carl Hanser Verlag GmbH & Co. KG; 10. Aufl. 2019
Fueglistaller et al. (2012), Entrepreneurship - Modelle - Umsetzung - Perspektiven. Springer Gabler Verlag. Wiesbaden;
Evobis Handbuch Businessplan-Erstellung. www.evobis.de;
Faltin (2008), Kopf schlägt Kapital. Carl Hanser Verlag. München;
Oehlrich (2013), BWL – Eine Einführung am Businessplan-Prozess. Verlag Franz Vahlen München.

**Responsible for Module:**
Röder, Hubert; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Business Analysis (Vorlesung, 1 SWS)
Röder H [L], Röder H

Business Planning (Übung, 3 SWS)
Röder H [L], Röder H
For further information in this module, please click campus.tum.de or here.

## Module Description

# ED160037: Circular Economy Spotlights: Technological Innovations and Sustainable Perspectives of the Circular Economy | Circular Economy Spotlights: Technologische Innovationen und Nachhaltigkeitsperspektiven der Kreislaufwirtschaft

Version of module description: Gültig ab summerterm 2024

| **Module Level:** Master | **Language:** German/English | **Duration:** one semester | **Frequency:** irregularly |
|---|---|---|---|
| **Credits:*** 3 | **Total Hours:** 90 | **Self-study Hours:** 75 | **Contact Hours:** 15 |

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

**Description of Examination Method:**
The module examination is an open book written exam composed of subtasks assessing the knowledge gained for each of the lecture themes as well as 1 reflective component. The tasks make out 80% of the total exam assessment and the reflective component is weighted 20%.

For each of the tasks, 2-3 reflective questions need to be answered. The duration of the exam will be 60 minutes.
• Online Exam: The examination will be conducted through a virtual platform (e.g. Moodle)
• Reflection Component: Students will be required to submit a reflective component consisting of multiple small mandatory reflection tests as part of the examination, providing insights into their holistic understanding and application of Circular Economy concepts. For the reflection component, Moodle will be utilized for reflection tests in the form of a 'Discussion Corner.' The plenary discussion feature on Moodle will serve as a space to reflect on lecture contents, allowing students, especially those who may not be familiar with each other due to the nature of the new module, to exchange perspectives on various insights and their content.
The reflective component will be weighted with 20% and should test the student’s understanding of the interconnectedness of the thematic explorations and reflect on the individual learnings in a broader context of the Circular Economy and its dynamic and evolving field of research.
• Open-Book Approach: The examination will adopt an open-book approach, allowing students to refer to course materials and resources during the assessment.
• Pass/Fail Grading: The examination will be graded on a Pass/Fail basis, emphasizing a holistic assessment of the student's overall comprehension, critical thinking, and new Circular Economy perspectives acquired by the students throughout the course.

A strongly suggested prerequisite for writing the exam is attendance on the lecture days (see Content).

The examination will primarily assess the following learning outcomes:

Comprehensive Understanding:
• Evaluate the student's fundamental understanding of Circular Economy, its principles, and its significance in the sustainability discourse, such as the connection between climate impact and Circular Economy
• Comprehend the diverse disciplinary lenses through which Circular Economy can be examined and the discipline-specific knowledge acquired in dedicated lectures.
• Understand the thematic breadth and complexity of the Circular Economy considering environmental, ecological, economic, and social perspectives.
Reflecting:
• Evaluate the complexity and multifaceted nature of the Circular Economy, considering different perspectives gained through the spotlight lectures.
• Assess the student's grasp of the importance of interdisciplinarity in the context of Circular Economy.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
None Specified

**Content:**
The module aims to offer a foundational understanding of Circular Economy, its thematic breadth and complexity by covering disciplines such as Engineering, Natural Sciences, Economics, Politics, and Management and suggesting a personalized approach. The concept is to provide insights across TUM locations and disciplines through expert-led lecture sessions inspired by existing courses. The module opens doors to a series of sustainability lectures, allowing students to delve into the diverse aspects of Circular Economy across different disciplines. For this, a clustered series of lectures and activities will be offered from different disciplines that allow joining without a specific prerequisite in the field.

Students will gain insights into Circular Economy concepts, including but not limited to covering disciplines such as Engineering, Natural Sciences, Economics, Politics, and Management. Opportunities for engaging with guest speakers are integrated into the portfolio, enriching the learning experience with real-world insights.

A kick-off and onboarding session will be organized to introduce participants to the module. Reflection on the learnings and expectations may be part of this initiation process as well as an ending event on the last day of lectures.

**Intended Learning Outcomes:**
After completion of the Circular Economy Spotlight lectures, the course participants will be able to:

o Understand the concept of the Circular Economy and its foundational principles.
o Explain the difference between the traditional linear economy as opposed to the concept of a Circular Economy.
o Gained specific knowledge and insights into Circular Economy aspects applied in multiple disciplines across TUM Schools and locations, such as within Engineering, Natural Sciences, Economics, Politics, and Management.
o Understand the relevance of interdisciplinarity for Circular Economy.
o Assess and reflect on the Circular Economy from an environmental, economic, and social perspective and understand its complexity and broadness of application in different fields.

**Teaching and Learning Methods:**
The teaching and learning methods for in-person lectures will predominantly rely on the individual speaker styles. As a result, these methods may vary from what is considered typical in different disciplines and may include:
- Media-assisted teacher-centered teaching based on presentations.
- Practical examples from guest lectures, providing insights into the subject matter from an applied perspective.
- Active participation in practical learning, such as - Dismantling and recycling exercises in the CE-lab
- Active participation in question rounds and discussions with the teacher and other students

In addition to the individual contact lectures, introductory sessions on the concept of Circular Economy will be held in a hybrid format, to participate in live, recorded, or online lectures, giving them the flexibility to rewatch the content throughout the entire duration of the module.
In addition, part if the self-study contains:
- reading of scientific publications
- plenary discussion through moodle to reflect on the lecture contents & to consolidate/repeat the learned contents

**Media:**
Kick-off online video, digital projector, board, flipchart, PowerPoints, online content, scientific journal publications
Online Information: e-learning course on moodle

**Reading List:**
An extensive reading list will be provided in the portfolio as preparation for each lecture. For introductory reading, please see the recommended reading below.
• Recommend Reading:
- Baccini, Peter (1991): Metabolism of the Anthroposphere, Springer
- De Angelis, Roberta (2018): Business Models in the Circular Economy: Concepts, Examples and Theory, Palgrave Macmillan

- Kirchherr, Julian & Reike, Denise & Hekkert, M.P.. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling. 127. 221-232. 10.1016/j.resconrec.2017.09.005.
- Wiesmeth, H. (2021): Implementing the circular economy for sustainable development. Elsevier, Amsterdam.
- Denise Reike, Walter J.V. Vermeulen, Sjors Witjes (2018) ,The circular economy: New or Refurbished as CE 3.0? — Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options,Resources, Conservation and Recycling,Volume 135,
- TUM Forum Sustainability – Circular Economy, Reichwald et al. 2022, TUM University Press
- Circular Economy Action Plan – COM (2020), European Commission
- Circular Economy Initiative Deutschland (Hrsg.): Circular Economy Roadmap für Deutschland, *Kadner, S., Kobus, J., Hansen, E., Akinci, S., Elsner, P., Hagelüken, C., Jaeger-Erben, M., Kick, M., Kwade, A., Kühl, C., Müller-Kirschbaum, T., Obeth, D., Schweitzer, K., Stuchtey, M., Vahle, T., Weber, T., Wiedemann, P., Wilts, H., von Wittken, R. acatech/SYSTEMIQ, München/London 2021.DOI: https://doi.org/10.48669/ceid_2021-3

**Responsible for Module:**
Fottner, Johannes; 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

## MGT001459: TUM Climate Ventures | TUM Climate Ventures

Version of module description: Gültig ab winterterm 2024/25

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>135 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
This module's learning objectives are examined via exercises (“Übungsleistung”) comprising the three elements outlined below. There is no written exam.

(1) Individual written reflection paper (10%): At the end of each session, you will submit a short reflection paper of 1/2 page (font size 12; double line spacing) highlighting the key learnings of the course and explaining why, how, and where they might influence your project. The individual reflection will show that you can process, synthesize, and prioritize the newly learned knowledge and critically think about and argue for more expansive fields of application beyond those discussed in class.

(2) Group presentations (60%): During the class, there will be three presentations: (1) A pitch in the first weeks of the course (2 minutes), (2) a midterm pitch (10 minutes), and (3) a final pitch (15 minutes). Each pitch has to reflect the content of the course. In the session, you will present a part of your group's climate venture. As each member of the group will present, your individual contribution is clearly identifiable and appraisable. The final group presentation will showcase that you are able to synthesize and present your findings in a comprehensive, precise, and structured way. It will also show that you communicate clearly and perform professionally. The final pitch will be graded.

(3) Group written reporting (30%): As part of a group composed in the first two weeks of the course, you will work on a climate venture project by assessing, analyzing, and designing climate-tech venture related strategies and actions. This assessment will show that you can directly apply the learned frameworks, theories, and concepts to uncover and assess the implications of climate ventures, determine and evaluate suitable climate ventures strategies, prioritize and initiate actions and decisions for their implementation, identify predictors of failure, and propose mitigative steps. It also illustrates that you can collaborate in a team, adopt a leader's perspective, strategize,

and solve problems in an analytical and structured way. The reporting includes the submission of a weekly (1) agenda for office hours meetings, a weekly update of an (2) interview tracking spreadsheet (approximately 50 interviews with experts and potential customers that you will conduct between week 3-13), and (3) the pitch decks of your presentations. An assessment sheet filled in by each group member and handed in at the end of the course will clarify your individual contribution.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
The course is looking for two different skill sets. You should either have advanced entrepreneurial knowledge and experience through courses, practical experience, or advanced programs like Manage&More or CDTM, or you have advanced technological understanding of relevant climate tech applications.

**Content:**
Building climate ventures that have impact can be a very complex and demanding challenge. Often this requires an expanded skillset of how to identify, assess, analyze, design, build, and launch climate-tech ventures, as well as high team effort, and very strong leadership. In addition, dynamic markets, technological uncertainties and grand challenges create additional pressures on novel ventures understanding their impact. This module provides a holistic view of the climate venture process in a real-world project. It introduces you to theories, concepts, and frameworks for climate ventures. Students will gain hands-on experience in the startup process, learning how to identify, assess, analyze, design, build, and launch climate-tech ventures.

Emphasis will be placed on effective collaboration within interdisciplinary teams to tackle real-world climate challenges. The course will help students build a strong climate-tech network and community, providing opportunities for collaboration and support. Students will work on creating new companies aimed at addressing high-impact climate problems, from ideation to market entry.

Exploration of breakthrough technologies and their potential applications in solving global climate issues will be a key component of the course. Students will understand the fundamentals of economic and technical evaluations specific to the climate-tech industry. The course will teach customer-centric approaches to developing climate solutions, emphasizing the importance of understanding and addressing customer needs.

Navigating the regulatory and market landscapes influencing climate-tech ventures will also be covered, helping students understand the broader context of their projects.

**Intended Learning Outcomes:**
Upon successful completion of this module, you will be able to:
Course Learning Goals:

1. Analyze relevant technical, business, political, and social drivers and barriers behind a vexing climate-tech challenge and design a solution as a team to address it.
2. Synthesize insights from research, analysis, and external engagements to compose a compelling value proposition around a new venture.
3. Evaluate and iterate through the potential success of a venture plan that meets the criteria of high impact, white space, unique value proposition, and self-sustainability.

Knowledge objectives:
(1) Explain and apply key concepts, frameworks, and theories related to climate ventures in practice
(2) Uncover and assess the implications of relevant technical, business, political, and environmental drivers and barriers behind climate tech ventures
(3) Determine and evaluate climate venture strategies considering venture-specific and contextual factors through research and external feedback
(4) Prioritize and initiate actions and decisions for implementing climate tech ventures with impact
(5) Identify predictors of failure and propose mitigative steps
Competencies objectives:
(1) Improve analytical, structured problem-solving, synthesis, and prioritization competencies
(2) Enhance team collaboration and leadership competencies
(3) Strengthen communication, presentation, and argumentation skills
(4) Build up critical thinking and strategizing competencies
(5) Perform under a maximised degree of realism in building a venture

**Teaching and Learning Methods:**
The module consists of an introductory session in which the fundamentals of climate ventures will be shared and discussed. In addition, groups will be matched and assembled, and each group will work on a real-world climate-tech venture for which a business case will be jointly developed throughout the course.

In subsequent sessions, module contents will be co-developed by the course participants, the instructor(s), and guest lecturers. To enable building up a solid knowledge fundament, we integrate action-learning elements such as presentations and discussions of course material, interview results, and relevant publications; individual mentoring; and interactions with industry and venture capital guest speakers.

Continuous mentoring on the climate-tech ventures will ensure that the newly acquired knowledge will be directly applied. Groups are asked to gather information on their climate venture cases through approximately 50 interviews.
Hence, a large share of learning will occur through your individual and your group’s preparation for the in-class sessions and working on your climate venture projects. Respective instructions and materials to prepare will be given throughout the course.

Through presentations, discussions of intermediate findings, guest lectures, and feedback provided by the instructor(s), mentors, industry experts and venture capitalists, you will be able to share and get an assessment of your progress continuously. The module will end with a group presentation followed by a moderated Q&A and joint reflection exercise.

**Media:**
Presentations, flipchart, whiteboard, digital tools, videos, Zoom (for feedback sessions)

**Reading List:**
Class materials, lecture slides, suggested readings, other materials recommended for each team and guest speaker slides will be posted on Moodle.

**Responsible for Module:**
Tryba, Anne; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
TUM Climate Ventures (MGT001459, englisch) (Seminar, 4 SWS)
Tryba A [L], Eiermann-Hüser L, Lara Vargas L, Reiter S
For further information in this module, please click campus.tum.de or here.

# Module Description

## WI001181: Advanced International Experience | Advanced International Experience

Version of module description: Gültig ab summerterm 2021

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>6 | **Total Hours:**<br>180 | **Self-study Hours:**<br>180 | **Contact Hours:**<br>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.mgt.tum.de/download-center)

**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, WIHN1181, englisch) (Vorlesung, 4 SWS)
Richards M [L], Richards M, Zösmair S, Safieh M
For further information in this module, please click campus.tum.de or here.

# Electives Engineering and Natural Science | Electives Engineering and Natural Science

## Module Description

### WZ1193: Biogas Technology | Biogastechnologie [BiGA]

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>100 | **Contact Hours:**<br>50 |

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

**Description of Examination Method:**
Students take a written examination (90 minutes) to demonstrate their knowledge of microbial breakdown processes in the biogas process, as well as their ability to assess influencing factors. They also demonstrate their knowledge of various technologies for using biogas and can explain their respective advantages and disadvantages. Additionally, they demonstrate that they have understood the legal and economic framework conditions of biogas technology and are able to translate these to case examples. Students also show that they can develop basic concepts of biogas plants.They will answer questions on the topic in their own wording and explain case examples or work out calculations. Multiple-choice questions are also possible.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Required: basic knowledge in biology, especially microbiology, as well as general and organic chemistry, mathematics, physics and thermodynamics of cycles; of advantage: knowledge in agriculture and agricultural engineering

**Content:**
Microbiology of biogas processing, anaerobic substrate breakdown, factors influencing the fermentation process, process management strategies, biogas storage and purification; biogas recovery (e.g. use of a motor for power generation with or without the use of heat or feeding into the gas grid); legal-economic framework conditions; sustainability issues; competition for raw material and acceptance of biogas plants; aspects of biogas plant design.

**Intended Learning Outcomes:**
After successful completion of the module, students are able to develop concepts for biogas generation and recovery in a specific context. Students are aware of microbial breakdown processes in biogas plants and can differentiate between various influencing factors. They are also aware of various processes for the use of biogas and understand their advantages and disadvantages. Students recognize the meaning of biogas technology for sustainable energy supply. Students have a good knowledge of legal and economic framework conditions in the field of biogas generation and they are able to conceptualize basic biogas plants.

**Teaching and Learning Methods:**
Lectures given as presentations, with the help of a blackboard and interactive elements, in particular group work on case examples; optional: excursion to a biogas plant to deepen acquired knowledge in a real-life setting

**Media:**
PowerPoint presentation, slide notes, exercise sheets

**Reading List:**
D. Deublein, A. Steinhauser, Biogas from Waste and Renewable Resources - An Introduction, Wiley-VCH, 2010, ISBN-13: 978-3-527-32798-0, ISBN-10: 3-527-32798-3

**Responsible for Module:**
Doris Schieder (doris.schieder@tum.de)

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

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

## Module Description

# CS0003: Production of Renewable Fuels | Production of Renewable Fuels

Version of module description: Gültig ab winterterm 2023/24

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The learning results are going to be proven in form of a written exam of 90 Minutes. Along the problem set, it is checked whether the student is able to understand, improve and assess industrial processes for the production of renewable fuels. No aids permitted.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Basic knowledge in chemistry, Fundamentals in Thermodynamics (e.g., Grundlagen der Thermodynamik), Fundamentals in Process Engineering (e.g., Introduction to Process Engineering)

**Content:**
Requirements for fuels, linkage of energetic and chemical value chains, fossil fuel production as reference, balancing and assessments (Well-to-Wheel), Hydrogen and methanol economy, alternative fuels on C1-basis, fisher-tropsch fuels, OME, bio-based oil fuels, biodiesel, green diesel, HEFA, bio-based alcohols, legislation of fuels.

**Intended Learning Outcomes:**
This module aims at making the students familiar with the industrial processes to produce renewable fuels. They are able to set up material and energy balances of these processes and assess their sustainability. Limitations with respect of raw material supply, energetic efficiencies and market requirements are understood. The students understand the interactions of fuel market and energy market.

**Teaching and Learning Methods:**
The module consists of a lectures and exercises. Contents of the lecture shall be imparted in speech and by presentation. To deepen their knowledge students are encouraged to study the literature and examine with regards to content the topics. In the exercises learned theory is applied with a practical orientation by means of arithmetic examples.

**Media:**
Hybrid live lectures & asynchronous mini-videos allowing distance learning, lecture Script and exercises via online platform, excursions to fuel production plants

**Reading List:**
• Jacob A. Moulijn, Michiel Makkee, Annelies E. van Diepen: Chemical Process Technology, Wiley (2013).
• George Olah et al.: Beyond Oil and Gas: The Methanol Economy, Wiley VCH (2006)
• Volker Schindler: Kraftstoffe für morgen: Eine Analyse von Zusammenhängen und Handlungsoptionen, Springer (1997)
• Martin Kaltschmitt, Hans Hartmann, Hermann Hofbauer: Energie aus Biomasse; Grundlagen, Techniken und Verfahren,SpringerVieweg (2016)
• Jochen Lehmann, Thomas Luschtinetz: Wasserstoff und Brennstoffzellen, Springer (2014)

**Responsible for Module:**
Burger, Jakob; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Production of renewable fuels (Tutorial, Straubing) (Übung, 2 SWS)
Burger J [L], Burger J, Groh D, Rosen N

Production of renewable fuels (Tutorial, Garching) (Übung, 2 SWS)
Burger J [L], Burger J, Groh D, Staudt J

Production of renewable fuels (Lecture, Straubing) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Staudt J

Production of renewable fuels (Lecture, Garching) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Staudt J
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0008: Enzyme Engineering | Enzyme Engineering [EE]

Version of module description: Gültig ab summerterm 2022

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
To proof whether the students are able to show ways to optimize enzymes in their properties and to perform this methodically, a written examination takes place with a duration of 60 minutes and a written seminar report must be created.The total grade consists of the written exam grade (67%) and the grade of the seminar report (33%).

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
This course aims to convey molecular biology and protein chemistry approaches to optimize enzymes especially by variation of the primary structure. Essential contents are: analysis of the limitation at the molecular level, rational methods, computer-based methods, evolutionary and combined procedures, high-throughput methods, robotics. The seminar aims to convey basic bioinformatical tools used in rational enzyme design such as ligand docking, energy minimization and rational introduction of mutations. These methods will be practiced on real enzymes and used to generate improved enzyme variants for a specific engineering target.

**Intended Learning Outcomes:**
After participating in the lecture the students will be able to indicate options for the improvement of technically limited enzymes, to estimate the necessary effort for these improvements and they own the theoretical ability to put these improvements into practice. After having participated in the seminar the students are able to use different bioinformatical tools for rational enzyme design and are able to evaluate the results of the generated informatical predictions.

**Teaching and Learning Methods:**
The lecture will be performed as ex-cathedra teaching to provide the students with all necessary fundamentals. In addition, the students review single methods and procedures by themselves e.g. based on current scientific literature and present this review to each other in a presentation. In the seminar, the students will be guided through the single steps of a rational enzyme engineering approach with the help of a script. The results of these steps will be summarized in a written report to put the single steps into a larger context.

**Media:**
PowerPoint, lecture script, scientific publications

**Reading List:**
Recommendations:
"Directed Enzyme Evolution: Screening and Selection Methods” (Methods in Molecular Biology) and “Directed Evolution Library Creation: Methods and Protocols” (Methods in Molecular Biology), both Frances H. Arnold, George Georgiou (publisher), Springer, Berlin
“Protein Engineering Protocols” (Methods in Molecular Biology), Katja M. Arndt and Kristian M. Muller (publisher), Springer, Berlin.

**Responsible for Module:**
Sieber, Volker; 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

## CS0009: Enzymatic Biotransformations | Enzymatic Biotransformations [IBT]

Version of module description: Gültig ab winterterm 2023/24

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
The students should be able to understand and describe possibilities and limitations of established industrial enzymatic processes. This understanding and its application to derive ways to improve existing processes, making them more sustainable and to establish new ones, a written examination takes place with a duration of 90 minutes (approved tool: calculator). As a voluntary mid-term effort, the students can take part in three online test within the Moodle course of the exercise. If they achieve at least 65% of the points in these tests, a bonus of 0.3 will be credited on the grade of the written examination (however, an improvement of the grade from 4.3 to 4.0 is not possible).

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
The lecture provides a broad overview about applications of enzymes in industrial processes and detailed insight into the corresponding technically important aspects by means of current examples. Essential contents are: industrially relevant properties of enzymes, essential enzyme classes and the most important enzymatic mechanisms, whole cell catalysis vs. enzyme catalysis, biocatalysis vs. classical chemical catalysis, methods of enzyme immobilization, enzymes in aqueous and non-aqueous systems, enzymatic reactions combined with chemical reactions, large-scale supply of enzymes. On the application side, biotransformations which are necessary for the conversion of biogenic ressources are treated as well as reactions for the synthesis of bulk chemicals, fine chemicals and food additives.

**Intended Learning Outcomes:**
After participating in the lecture the students will be able to review possible applications of enzymes in different chemical and technical processes, to understand the behaviour and limitation of enzymes in these processes and to derive ways to establish new reactions biocatalytically and to propose technically meaningful scenarios for newly developed enzymatic processes respectively.

**Teaching and Learning Methods:**
The lecture will be performed as ex-cathedra teaching which is interrupted by queries to familiarize students with all necessary basics and to stimulate independent, critical thinking. In the exercise, the students will deepen the knowledge they have learned and solve specific problems of varying complexity, either alone or in group work.

**Media:**
PowerPoint, white board, exercise sheets or online questions

**Reading List:**

**Responsible for Module:**
Sieber, Volker; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Enzymatic Biotransformations (Exercise) (Übung, 1 SWS)
Sieber V [L], Arana Pena S, Hupfeld E

Enzymatic Biotransformations (Lecture) (Vorlesung, 2 SWS)
Sieber V [L], Sieber V
For further information in this module, please click campus.tum.de or here.

## Module Description

### CS0012: Artificial Intelligence for Biotechnology | Artificial Intelligence for Biotechnology [AI]

Version of module description: Gültig ab summerterm 2024

| 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 module examination takes the form of a presentation followed by discussion. The learning outcomes are verified by a group project (3-4 students per group). The presentation of the developed code and the results of the project will be done together as a group, with each group member presenting one part. The presentation should be equally divided among the group members. After the presentation, each group member is asked individual questions about the project. The final grade will be based on the presentation and results of the project (duration of presentation and questions: approx. 30 min depending on group size; approx. 8-10 minutes per student). As a voluntary mid-term effort, the students can take part in a multiple-choice test (duration: 10 minutes). If they achieve at least 65% of the points in this test, a bonus of 0.3 will be credited on the grade of the presantation (however, an improvement of the grade from 4.3 to 4.0 is not possible).

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Mathematical Skills in Linear Algebra and Statistics as well as Programming Skills in Python are expected

**Content:**
Technologies that generate analyses or predictions based on data can be found in almost all areas of our daily life (e.g. recommender systems, autonomous driving, and credit card fraud detection). These methods are also important for analyzing biological and biomedical data, e.g. for finding novel patterns in biological data, predicting the disease state of a patient, or the 3D structure of proteins. In this course, we will learn the fundamentals of machine learning and will apply these methods to various real-world problems.

The following contents will be treated exemplarily:
- Similarity and Distance Metrics
- Data Preprocessing and Visualization
- Dimensionality Reduction (e.g., Principal Component Analysis)
- Classification (Nearest-Neighbor, Logistic Regression, Decision Trees, Support Vector Machines (SVM))
- Model Selection and Hyperparameter Optimization (Confusion Matrix and Evaluation Measures, Cross-Validation, Hyperparameter tuning techniques, Common problems such as Over- vs. Underfitting)
- Clustering (K-Means, Hierarchical Clustering)
- Regression Models (Linear Regression, Support Vector Regression)

AI-based technologies have the potential to support many areas of biotechnology and sustainability, e.g. by guiding downstream research with data-driven predictions or supporting decision-making with demand forecasts. In this course, we will look at suitable practical examples and demonstrate their potential.

**Intended Learning Outcomes:**
The students know the fundamental and most important artificial intelligence, especially machine learning, methods and are able to apply them independently on various real-world problems. The students learn the basics of the programming language Python (one of the leading programming languages in the field of machine learning) and are able to implement and apply machine learning algorithms in Python. In addition, students are able to visualize and interpret different types of data and results independently. Students will understand how artificial intelligence can support areas of biotechnology and sustainability and are able to assess the potential of AI-based approaches in sustainability projects.

**Teaching and Learning Methods:**
Lectures to provide the students with all necessary fundamentals of artificial intelligence, especially of machine learning which they will need to independently apply these concepts to real-world data. In the exercises the students are introduced to the programming language Python, as well as to apply and implement these algorithms for specific case studies.

**Media:**
The lecture shall mainly be done by using PowerPoint presentations. During the exercise the students work at PCs to gain confidence in using the programming language Python. Students implement various machine learning methods in Python (e.g. using Jupyter Notebooks) and apply them on various examples. Students work on real world problems to implement learnt skills and to gain confidence in applying these different methods independently.

**Reading List:**
Murphy, K. P. (2012). Machine learning: a probabilistic perspective. MIT press.
Bishop, C. M. (2006). Pattern recognition and machine learning. Springer.
Raschka, S. (2017). Machine Learning mit Python. mitp Verlag.

Friedman, J., Hastie, T., & Tibshirani, R. (2001). The elements of statistical. Springer.

**Responsible for Module:**
Grimm, Dominik; 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

## CS0019: Chemistry of Enzymes | Chemistry of Enzymes [COE]

Version of module description: Gültig ab winterterm 2022/23

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

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

**Description of Examination Method:**
To proof whether the students are able to understand and to describe more complex enzymatic reaction mechanisms and deduce starting points for new enzymes from that, an oral examination takes place with a duration of 30 minutes.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**

**Content:**
The lecture first gives an insight into the kinetic processes of enzymatic reactions and their descriptions. Then the katalytic mechanisms from a chemical point of view are presented and analyzed by means of enzymes of all six enzyme classes (e.g. acid/base catalysis in hydrolases, one-electron reactions, oxygenation, radical catalysis etc), whereby here more complex mechanisms are illuminated. The different coenzymes are introduced and their interaction with the substrates and the protein backbone is explained. For selected enzymes the mechanisms are presented in relation to the applications.

**Intended Learning Outcomes:**
After participating in the module sessions, students will be able to understand which complex catalytic mechanisms proceed in enzymes and how they are analyzed. This enables them to assess which chemical reactions are enzymatically possible and which non-natural modifications are necessary to establish new reactions. Thus, the students can for example open up the function of newly found enzymes and develop new enzymes

**Teaching and Learning Methods:**
The lecture will be performed as ex-cathedra teaching to familiarize the students with all necessary basics. The lecture is interrupted by short exercises/question-answer units to stimulate independent, critical thinking. In the seminar, the students will acquire the mechanisms for selected enzyme systems in self-research, introduce them to their fellow students and solve in a group work concrete problems of varying complexity.

**Media:**
PowerPoint, script, task sheets

**Reading List:**

**Responsible for Module:**
Dr.-Ing. Ammar Al-Shameri

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

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

## Module Description

### CS0026: Advanced Concepts of Bioinformatics | Advanced Concepts of Bioinformatics

Version of module description: Gültig ab winterterm 2023/24

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Learning outcomes shall be verified in a written test. Tasks shall be specified by means of which the students are to demonstrate that they know the bioinformatic methods imparted as part of the module and that they have understood and are able to apply them for specific case studies. Exam duration: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Module Biochemistry, WZ1631 Bioinformatics, CS0001 Foundations of Computer Science, Knowledge Linux Command Line Interface, Programming Skills in Python

**Content:**
In this course state-of-the-art methods in statistical genetics, genome-wide association studies, analysis of complex biological networks, protein-analysis as well as modern machine learning methods for genomic data are investigated and applied on various case-studies.

**Intended Learning Outcomes:**
The students know state-of-the-art bioinformatics methods and are able to apply them independently on various real-world problems. The students lern to implement custom Python scripts to analyse, visualise and interprete the results of these methods independently.

**Teaching and Learning Methods:**
Lectures to provide the students with the theoretical and practical concepts of state-of-the-art bioinformatics methods, which they will need to independently apply these methods on real-

world data. In the exercises the students will apply these tools on concrete case studies and will implement custom Python scripts to analyze, visualize and interpret the results.

**Media:**
The lecture shall mainly be done by using PowerPoint presentations. During the exercise the students work at PCs to gain confidence in using the bioinformatics tools. Students implement various custom Python scripts (e.g. using Jupyter Notebooks) to analyze, visualize and interpret the results of these tools. Students work on real world problems to implement learnt skills and to gain confidence in applying these different methods independently.

**Reading List:**
Pevsner, J. (2017). Bioinformatics and functional genomics. Wiley Blackwell.

**Responsible for Module:**
Dominik Grimm

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

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

# Module Description

## CS0032: Seminar on Optimization Methods and their Application | Seminar on Optimization Methods and their Application [SemOMA]

Version of module description: Gültig ab summerterm 2023

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The examination consists of a written seminar paper as well as an oral presentation & discussion. The seminar paper should cover 15–20 pages and be written in the style of current publications of peer-reviewed journal articles. In addition to the seminar paper, optimization models and methods may have to be implemented in order to conduct numerical analyses, which will be handed in as a digital appendix. At the end of the module, students present their work in a 45 minutes presentation. Both parts (the written paper and the presentation) are weighted equally to the final grading.

**Repeat Examination:**

**(Recommended) Prerequisites:**
The module covers optimization models and methods and their application in operations research. To study these models and methods, methodological knowledge on optimization methods as obtained, e.g., in the module CS0098 (Operations Research) is required.

**Content:**
The seminar focuses on recent research developments on varying topics related to optimization methods and their application in operations research. Students learn to model practical problems arising in different areas of operations research as optimization problems and to solve the resulting problems using suitable methods. Thereby, mathematical optimization models and methods from areas such as (mixed-integer) linear programming and network optimization (e.g., shortest path or network flow problems) are used to solve relevant practical problems.

**Intended Learning Outcomes:**
The objective of the module is to equip the participants with the necessary skills for writing academic papers and tools for a successful master’s thesis project.

Specifically, the aim is to be able to:
- Read and understand recent research contributions
- Pursue interesting and relevant research questions
- Conduct a literature study and/or numerical study and/or implementation concerning a specific topic
- Structure and organize research methods and results
- Write a seminar paper
- Present research findings and defend them in an academic discussion

**Teaching and Learning Methods:**
In an introductory session, the current theme of the module is explained by the lecturer and the various available seminar topics are elaborated in detail. Moreover, information on relevant literature for the problem settings is introduced, which forms the basis of the students' seminar papers. After the introductory session, students will work out their assigned topics independently own or in small groups by using their abilities of conducting literature research, mathematical modelling, programming, and quantitative analyses. Throughout the project, they receive guidance from a supervisor. Different milestones such as a preliminary outline of the seminar paper, first research results, and the final paper are to be achieved. Following the submission of the final paper, presentations and discussions of all students' seminar papers are conducted, where also presentation, moderation, and discussion skills are trained.

**Media:**
Research paper; presentation slides

**Reading List:**
F. Petropoulos et al. - Operational Research: Methods and Applications, Journal of the Operational Research Society, Volume 75, Issue 3, pp. 423-617 (2024)
M. Carter, C. C. Price, G. Rabadi - Operations Research: A Practical Introduction (2nd ed.), Chapman and Hall/CRC (2018)

**Responsible for Module:**
Thielen, Clemens; 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

## CS0086: Wood-based Resources | Wood-based Resources

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Exam achievement shall be done in the form of a test. Product pathways of forestry and forest industry shall be reflected here. Classification of economic and ecological aspects of forestry and forest industry from cultivation to material and energetic use shall be explained by using examples of particular cases. Recognition of wood and wood materials shall be shown. The relation of knowledge of forestry and forest industry with regard to knowledge of different woods and wood utilisation will be evaluated at a ratio of 1 to 1. The answers require own formulations from the respective technical jargon of forestry and forest industry.
Type of exam: In writing. Exam duration: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**

**Content:**
The module aims at providing in-depth knowledge to the students in the field of forestry and forest industry from harvest to the use of wood. Special emphasis is given to the interfaces concerning wood use (sawing, wood materials and paper industry) and energy wood production. In a further aspect differences of woods shall be addressed from a microscopic point of view through to their field of application in the manufacturing industry. Therefore, students learn to classify woods microscopically and macroscopically.

**Intended Learning Outcomes:**
After attending the module the student shall be able to characterise the product pathways in forestry from crop establishment through to material and energetic use of wood. He distinguishes different forms of economy and is able to classify them according to economic, social and

ecological aspects. He recognises differences of woods, knows various new products produced from wood and understands their production paths and their markets.

**Teaching and Learning Methods:**
The course attendance of forestry and wood consists of a lecture and exercises. For this purpose powerpoint presentations amd practical training material shall be used. A study trip to wood processing plants including lectures from qualified personnel providing information from experience on site with common rounds of questions provides in-depth knowledge of the production paths. A socalled wood block determination, i. e. the determination of wood by means of different genuine wood samples, will be performed by a magnifying glass 10x.

**Media:**
The following forms of media apply: Script, powerpoint, films, for determination exercises also branches and leaves of shrubs to be determined. Study trip to companies with guided tour of processing and treatment of wood. Determination of wood with a magnifying glass 10x.

**Reading List:**
D. Fengel and G. Wegener: Wood. Publisher: De Gruyter, https://doi.org/10.1515/9783110839654
Jörg van der Heide, 2011: Der Forstwirt. (The Forester) Publisher: Ulmer (Eugen); Auflage: 5th edition. (September
26, 2011)
Language: German
ISBN-10: 3800155702
ISBN-13: 978-3800155705; D. Fengel, G. Wegener: Wood Verlag Kessel, www.forstbuch.de

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Wood-based Resources (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Röder H, Zollfrank C

Wood-based Resources (Exercise) (Übung, 2 SWS)
Zollfrank C [L], Röder H, Zollfrank C
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0100: Microbial and Plant Biotechnology | Microbial and Plant Biotechnology [MPBioTech]

Version of module description: Gültig ab summerterm 2023

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

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

**Description of Examination Method:**
In order to check whether students have understood and are able to apply the principles and relevant methods and techniques of biotechnological production processes, the students answer questions about production processes and fermentation strategies, as well as on important methods and applications in plant biotechnology in a written exam (90 min) and prove that they have understood the correlations of metabolism. Allowed tools are calculators.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Fundamentals of Biology or of cell and microbiology from the Bachelor's courses

**Content:**
In the lecture microbial biotechnology relevant topics and techniques of microbial biotechnology are presented. This includes the quantitative description of the metabolic performance of microorganisms, industrially relevant substrate sources, metabolic engineering strategies as well as examples of industrial production processes (e.g.: alcohols, amino and organic acids).
In the lecture plant biotechnology the most important model and crop plants in biotechnology are presented, classified and their morphological and physiological properties are emphasized. Major questions, methods and solutions will be discussed with thier pros and cons. Some of the topics to be discussed: legal framework, major appilcation of current plant genetic engineering, the Arabidopsis model system, snovel concepts for yield and quality improvement. One focus is on the challenges for agriculture caused by climate change and sustainable solutions.

**Intended Learning Outcomes:**
Upon successful completion of the module, students will be familiar with the principles and techniques of relevant microbial bioprocesses. The students have acquired knowledge of fermentation processes and are able to develop strategies for process control for selected product classes. The students have learned to quantitatively describe microbial growth and fermentation processes. The students have acquired in-depth knowledge of relevant production processes for selected products of industrial biotechnology and understand their importance for the development of sustainable chemistry. Also, the students know the most important methods and applications in plant biotechnology and are able to assess them.

**Teaching and Learning Methods:**
The contents of the lectures are conveyed by a talk of the lecturer, based on PowerPoint presentations. The blackboard might additionally be used to explain more complex relationships. To a limited extent, this can be supplemented by self-study of the literature mentioned in the lecture.

**Media:**
PowerPoint, whiteboard

**Reading List:**
Microbiology – an evolving science, J. L. Slonczewski, J. W. Foster, W W Norton & Co Inc, 4th edition, ISBN: 978-0-393-61403-9 (available in the library)
Molecular Biology of the Gene, I. D. Watson, T. A. Baker, A. Gann, M. Levine,
Losick, Pearson, 7th edition, ISBN-13: 978-0321762436 (available in the library)
Biotechnology, R. D. Schmid, C. Schmidt-Dannert, Wiley-VCH, 1st edition,
ISBN: 978-3-527-33515-2 (available in the library, eBook)
Industrial Microbiology, D. B. Wilson, H. Sahm, K.-P. Stahmann, M. Koffas,
Wiley-VCH, 1st edition, ISBN: 978-3-527-34035-4 (available in the library)
Industrial Biotechnology – Products and Processes, C. Wittmann, J. Liao,
Wiley-VCH, volume 4, ISBN: 978-3-527-34181-8 (available in the library, eBook)
Industrial Biotechnology – Microorganisms, C. Wittmann, J. Liao,
Wiley-VCH, volume 4, ISBN: 978-3-527-34179-5 (available in the library, eBook)
Campbell Biology N. A. Campbell, L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky, J. B. Reece, Pearson, 11th edition (2018) (available in the library)

**Responsible for Module:**
Blombach, Bastian; Prof. Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Microbial Biotechnology (Vorlesung, 2 SWS)
Blombach B [L], Blombach B

Applied Microbiology and Metabolic Engineering (Lecture) (Vorlesung, 2 SWS)
Blombach B [L], Blombach B, Glawischnig E

Plant Biotechnology (Lecture) (Vorlesung, 2 SWS)
Glawischnig E [L], Glawischnig E
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0101: Renewables Utilization | Renewables Utilization

Version of module description: Gültig ab winterterm 2020/21

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Assessment takes a written examination (90 minutes), with students to unterstand and to apply structure, transformation and use of different renewable resources. Students are required to answer questions using individual formulations and outline structures and reactions. In addition, sample calculations are to be worked out.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic lectures in chemistry; Basics on renewables utilization

**Content:**
Various types of ingredients of renewable raw materials: sugars, polysaccharides, fats and oils, amino acids, proteins, terpenes, aromatics. The following topics will be dealt with in more detail: structure, composition, occurrence, properties, analysis and type of added value or use in various examples.

**Intended Learning Outcomes:**
After completion of the modules, students understand the chemical composition of renewable resources as well as their production and application. Using this knowledge students are able to explain the respective advantages and disadvantages as well as analyze the underlying physical, chemical and biotechnological principles of their conversion into valuable products.

**Teaching and Learning Methods:**
Lecture and accompanying tutorial including individual work on specific examples.

**Media:**
Presentation, script, examples and solutions

**Reading List:**

**Responsible for Module:**
Rühmann, Broder; Dr. rer. nat.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Renewables Utilization (Exercise) (Übung, 2 SWS)
Rühmann B

Renewables Utilization (Lecture) (Vorlesung, 2 SWS)
Sieber V [L], Rühmann B, Sieber V
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0102: Introduction to Game Theory | Introduction to Game Theory [IGT]

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
Learning outcomes are verified in a written exam (90 minutes). Students show the extent to which they have understood the taught game-theoretical definitions and terminology. They show to which extend they are able to use games in order to model problems from economics and engineering. They are also expected to apply important solution concepts to concrete games and answer comprehension questions concerning the properties and the advantages and disadvantages of the different solution concepts.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Module Mathematics (WZ1601) or Advanced Mathematics 1 (CS0175)

**Content:**
Cooperative and non-cooperative games, solution concepts for cooperative games, core, Shapley value, solution concepts for non-cooperative games, pure Nash equilibria, mixed Nash equilibria, dominant strategies, Bayesian games, modeling concrete case studies related to sustainability as cooperative and non-cooperative games

**Intended Learning Outcomes:**
Students have aquired basic theoretical and practical knowledge on cooperative and non-cooperative games. They know the basic definitions and terminology and are able to model sustainability-related problems from economics and engineering as games. Students know the most important solution concepts for cooperative games (such as the core and the Shapley value) and non-cooperative games (such as Nash equilibria and dominant strategies). They have gained a good understanding of these concepts and are able to analyze concrete games by using them.

**Teaching and Learning Methods:**
Lectures introduce basic knowledge; tutorials practice modelling of application problems as games and applying solution concepts to concrete examples.

**Media:**
Lectures given as presentations (projector and/oder blackboard), tutorials with group work and exercise sheets

**Reading List:**
Manfred J. Holler, Gerhard Illing, Stefan Napel - Einführung in die Spieltheorie, 8. Auflage, Springer Gabler, 2019.
Steven Tadelis - Game Theory: An Introduction, Princeton University Press, 2013.
M. J. Osborne and A. Rubinstein - A Course in Game Theory, MIT Press, 1994

**Responsible for Module:**
Thielen, Clemens; 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

## CS0104: Biogenic Polymers | Biogenic Polymers [Bioplar]

Version of module description: Gültig ab winterterm 2020/21

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
During the seminar, students independently work on a topic from the field of biogenic polymers, and give an oral presentation. Group work is optional. Assessment requires an oral examination (30 minutes). Students demonstrate their knowledge of physico-chemical properties of biogenic polymers as well as possible applications. Students are able to develop options for chemical synthesis and analysis of physico-chemical properties of bioplastics. No further tools are allowed in the examination.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Successful participation in "Basics in Chemistry" and knowledge of materials and chemical compounds, or comparable knowledge on chemistry and physics.

**Content:**
The module deals with structure and function of natural bio-macromolecules (in particular polysaccharids and proteins). Furthermore, basics of biogenic polymers will bei discussed in the view of polymers holding potential for applications in future technology. The topic of chemical synthesis and derivatization of bioplastics for use in industry is introduced (e.g. cellulose derivatives). Special focus is set on the development of options for chemical synthesis and its competent application. Physico-chemical properties of bioplastics as well as their characterization is central to the lecture.
The seminar takes the form of a journal club with students independently work on reserach papers and their presentation to fellow students.

**Intended Learning Outcomes:**
After participation, students are able to classify different kinds of bioplastics with respect to their possible application. They are competent to evaluate the production processes of biopolymers used in technology and can classify them according to their profile of properties. The module enables students to decide on appropriate synthesis methods to meet specific requirements in the industry. Students will also be able to use physico-chemical analysis methods in a competent way.

**Teaching and Learning Methods:**
Lecture (talks given by teaching staff using PowerPoint media, books and additional written document), seminar (independent work on a topic including a presentation, peer instruction and constructive criticism)

**Media:**
Presentations, slide notes

**Reading List:**
Endres, H.J., Seibert-Raths, A., Technische Biopolymere, Carl Hanser Verlag, München, 2009

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Biogenic Polymers (Seminar) (Seminar, 1 SWS)
Zollfrank C [L], Helberg J

Biogenic Polymers (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Zollfrank C
For further information in this module, please click campus.tum.de or here.

## Module Description

### CS0105: Modelling and Optimization of Energy Systems | Modelling and Optimization of Energy Systems [MOES]

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Assessment is done in a written examination (90 minutes). Participants of the course solve programming tasks to demonstrate that they are able to apply the methods aquired in the course. By answering questions related to case examples they show that they have learned to put things into their proper context.

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Bachelor modules Mathematics, Physics, Numerical Methods;
Basic knowledge in Energy technology; basic programming experience (ideally with Matlab)

**Content:**
Basics of Modelling and Simulation:
- physical models
- data-based models (look-up tables, polynomials, neural networks)
- methods for generating models
Fundamental optimization methods:
- linear optimization (linear regression)
- nonlinear optimization

**Intended Learning Outcomes:**
After attending the course the participants understand basic methods for creating models, simulation and optimization. In addition, they are able to apply these methods by creating appropriate program code in Matlab. Furthermore, the participants acquire Matlab programming experience.

**Teaching and Learning Methods:**
The module consists of a lecture and an excercise. Lectures include presentations whose content is deepened by solving excercise problems autonomously. In order to improve the learning outcome, participants work at homework excercise problems. These are discussed in the next lecture.

**Media:**
PP presentation, whiteboard, demonstration of programs

**Reading List:**
S. R. Otto & J.P. Denier, An Introduction to Programming and Numerical Methods in MATLAB, Springer, London, 2005
O. Nelles, Nonlinear System Identification, Springer, Berlin, 2010

**Responsible for Module:**
Kainz, Josef; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Modelling and Optimization of Energy Systems (Vorlesung mit integrierten Übungen, 4 SWS)
Kainz J [L], Kainz J
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0134: Conceptual Process Design | Conceptual Process Design

Version of module description: Gültig ab summerterm 2024

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

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

**Description of Examination Method:**
The exam performance is effected by an oral exam. It is reviewed whether the students know the fundamentals of conceptual design of chemical and biotechnological processes and if they can apply this knowledge on the design and evaluation of complex processes. The exam consists of two parts: (a) 30 minutes preparation through solving a given problem set (b) 30 minutes of oral examination. In the beginning of part (b) the results of part (a) are presented by the student. (total duration 60 min)

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Knowleadge of thermodynamics and apparatusses used for fluid sparations processes. It is recommended to visit at least the course "Introduction of Process Engineering" first.

**Content:**
Basics of cenceptual design of processes; Basics of computational process design including calculation of process parameters; transfer of fundamental scale-up criteria towards real problem solving; Balancing of all process streams; Deepened knowledge of engineering principles.

**Intended Learning Outcomes:**
The students are qualified to understand the fundamentals of design, calculations, and balancing of chemical processes and fluid separation courses after the course. They will aquire knowledge of different challenges of process design and how to master them.

**Teaching and Learning Methods:**
The module consists of lectures and parallel tutorials. Contents of the lecture shall be imparted in speech and by presentation. In the exercises performed as part of the module learned theory

shall directly be applied with a practical orientation by means of calculations and examples from targeted aspects of process design and calculation. based on a direct comparison of a chemical process with it´s biotechnical alternative they learn to apply their knowledge on reality based challenges. Additionally they will be qualified by an in-depth knowledge of the design of operation units including calculation of process parameters based on utilization of selected software tools.

**Media:**
Panel, slides, scripts, practical exercises

**Reading List:**
Moulijn et al. (2013). Chemical Process Technology. – John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, United Kingdom.
# Biegler et al. (1997). Systematic Methods of Chemical Process Design. – Prentice Hall.
# Doherty, M.F., Malone, M.F. (2001). Conceptual design of distillation systems. – Boston: McGraw-Hill.
# Gmehling, J., Kolbe, B., Kleiber, M., Rarey, J. (2012). Chemical Thermodynamics for Process Simulation. 1. Auflage. Weinheim: Wiley – VCH
# Grassmann, P., Widmer, F., Sinn, H. (1997). Einführung in die Thermische Verfahrenstechnik. 3. vollst. überarb. Auflage. Berlin: de Gruyter.
# Stichlmair, J.G., Fair, J.R. (1998). Distillation: Principles and Practice. – New York: Wiley – VCH.

**Responsible for Module:**
Burger, Jakob; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Conceptual Process Design (Lecture) (Vorlesung, 2 SWS)
Burger J [L], Burger J, Ibanez M, Staudt J

Conceptual Process Design (Exercise) (Übung, 2 SWS)
Burger J, Rosen N, Wolf A
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0147: Energy Efficient Buildings | Energy Efficient Buildings [EEB]

Version of module description: Gültig ab winterterm 2022/23

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

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

**Description of Examination Method:**
Students demonstrate their knowledge and understanding of the differenct aspects of energy efficient buildings in form of a written examination (90 minutes). Students deliver definitions, describe and outline relevant processes, mechanisms and requirements of energy efficient buildings. Furthermore, students calculate different technical specifications and parameters based on provided practice-oriented examples.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basics of physics, Basics of energy technology

**Content:**
The course focuses on the variety of options for implementation and/or enhancement of energy efficiency in new and existing buildings. This includes an introduction to relevant expert knowledge of energy and ressource efficient building materials and construction. In addition, typical measures for the enhancement of energy efficiency in existing buildings will be presented and evaluated concerning ther sustainability. The second part of the module is concerned with renerwable energy based systems for heat and warm water provision of buildings. Specific advantages and disadvantages of the presented technologies will be discussed in regards to building and usage type. In addition to the presentation of individual measures, it will be analyzed how concepts for energy efficient buildings can be include in modern building infrastructure and on living quarter scale.

**Intended Learning Outcomes:**
"After successful completion of the module, students acquire in-depth understanding of  factors determining the energy efficiency of buildings and relevant legal requirements. Students can

evaluate the sustainability of actions to enhance the energy efficiency of (existing) buildings. In addition, students can understand as well as evaluate and explain advantages and disadvantages of systems for heat and warm water provision based on renewable energies in regards to building and usage type.

Students prepare short, practice-oriented tasks as homework in a project team (group work). Thereby, they acquire the ability to view and assess information within a limited period of time and solve practice-oriented questions. The edited information and results are passed on to the other participants accordingly with the focus on sharing results in the form of a written report as well as team work.

**Teaching and Learning Methods:**
The content is taught in lecturs and presentations. In addition, case studies and exercises will bei discussed. Students should bei encouraged to individual literature study and discussions on the theme.

**Media:**
PowerPoint, blackboard, videos

**Reading List:**
Bauer, M., Mösle, P., Schwarz, M. (201.): Green Building: Leitfaden für nachhaltiges Bauen. Springer Vieweg. Daten von Fachagenturen: BINE Informationsdienst, vom Bundesumweltministerium bzw. entsprechenden Landesministerien und anderen internationalen Organisationen.

**Responsible for Module:**
Vienken, Thomas; 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

## CS0149: Renewable Resources in Medicine | Renewable Resources in Medicine

Version of module description: Gültig ab summerterm 2023

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The Assessment consists of a written examination (90 minutes)

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Requirements for the successful participation is basic knowledge in chemistry, cell and microbiology, biochemistry, materials science and renewable ressources

**Content:**
The course provides basic knowledge on the human anatomy, cell biology on general and the cell membranes in particular. The interaction of materials with cell surfaces and tissue will be introduced. The general issues related to pharmacology and the fabrication of drugs from from renewable ressources will be discussed.  The application of renwable resources as the main course topic in surgery, internal medicine, plastic and reconstructive surgery as well as wound dressings will introduced. Future tasks for the medical application of renewable resources are outlined. The legislative framework for application of medical products and fabrication will be discussed.

**Intended Learning Outcomes:**
The successful visit of this course enables the students to select materials from renewable ressources for relevant fields in medicine (skin, muscle, bone) and can particularly assess the valueof their applicability. They are able to apply the most important legislation in medical application and to validate the material reqeuiements  for the application in humans (biocompatibility). They are able to identify and develop new concepts for sustainable materials

from renwable ressources in medicine due to their aquired medical, chemical and materials science knowledge and they can set the base for the potiental application of such materials.

**Teaching and Learning Methods:**
Lecture (talk by teaching staff) with media, seminar on case studies

**Media:**
Presentation, script, examples, case studies

**Reading List:**
The following literature is recommended: Buddy Ratner et al.: Biomaterials Science - An Introduction to Materials in Medicine, Elsevier

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

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

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

## Module Description

# CS0156: Material Application for Renewable Resources | Material Application for Renewable Resources

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
During the seminar, students independently work on a selected topic from the field of biobased materials and give an oral presentation with PowerPoint-handout (min. 10 slides). Group work is compulsory (3 – 5 persons). The students will implement their own online survey and present the findings in the context of the relevant literature in the presentation (each student has to present 5 minutes). The oral presentation shall be assessed according to content of the PowerPoint-handout and rhetoric aspects. The PowerPoint-handout summarizes the relevant literature, data, and key findings. Weighting: PowerPoint-handout 1, oral presentation 1.
The seminar work is not part of the written exam. However, midterm bonus points can be achieved which will have an effect on the individual final grade (-0,3).

Assessment requires a written examination (90 minutes). Students demonstrate their knowledge of physico-chemical properties and possible applications of biobased materials, as well as their environmental impact. Students are able to develop options for chemical synthesis and production processes of biobased plastics. No further tools are allowed in the examination.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Successful participation in  "Basics in chemistry " and “Biogenic Polymers”, as well as knowledge of materials and chemical compounds, or comparable knowledge of chemistry and physics.

**Content:**
Lectures give an overview the applications for biogenic resources in materials industry. Starting with the chemical composition and physic-chemical properties of the raw materials, the module introduces students to production and processing of biodegradable and non-biodegradable

bioplastics, as well as of natural fibre composites. It also covers material properties, relevant fields of application, their environmental impact, as well as current market trends.
In the seminar, students independently work on research papers and based on that, give a presentation to fellow students.

**Intended Learning Outcomes:**
After successful participation, students are able to assess opportunities and barriers for the application of biobased plastics, as well as their environmental impact compared to conventional plastics. Above all, they are competent to select suitable feedstocks, classes and types of materials, as well as processes to meet the technical requirements of a specific target product, having lower environmental impact at the same time.

**Teaching and Learning Methods:**
Lecture (talks using PowerPoint slide media, books and additional written material), seminar (independent work on a selected topic with subsequent presentation, peer instruction and constructive feedback).

**Media:**
Presentations, slide notes

**Reading List:**
Endres, H.J., Seibert-Raths, A., Technische Biopolymere, Carl Hanser Verlag, München, 2009
Pickering, K. L. (Hrsg.): Properties and performance of natural-fibre composites, CRC Press, Boca Raton 2008
Lewin, M.(Hrsg.): Handbook of Fibre Chemistry, Marcel Dekker, New York, 1998

**Responsible for Module:**
Fink, Bettina; 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

## CS0164: Basics of Numerical Methods and Simulation | Basics of Numerical Methods and Simulation [NumS]

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Examination shall be done in the form of a written test. As an aid the materials (lecture slides, example programs) used during the lecture may be employed. The students show by solving programming tasks that they know the basics of Matlab and are able to employ it to implement simple numerical methods. They apply these methods to specific technical problems in case studies. In doing so, they also demonstrate their capability to discern which way to solve a problem is appropriate.
Exam duration: 90 minutes

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
WZ1600 Physics, CS0 Mathematics

**Content:**
- Basics of programming using Matlab/Simulink
- simple numerical methods: Systems of linear equations, numerical integration & differentiation, finding zeros,
- numerical solution of differential equations
- application of methods by using case studies (e.g. mechanical and electric systems)
- basics of optimization

**Intended Learning Outcomes:**
After having participated in the module units the students understand basic concepts of various numerical methods. They can apply these methods to case studies presented in the course methods using self-created programs in Matlab/Simulink. In doing so, they have also learned

to implement different solutions and discern how appropriate to the problem they are. In simple cases, they are also able to evaluate their results in terms of plausibility and accuracy.

**Teaching and Learning Methods:**
The module consists of one lecture and an associated session of exercises. Contents of the lecture shall be imparted in a speech and deepened through independent preparation of exercises by the students. Processing of exercises is often done by independent preparation of programming tasks.

**Media:**
Presentations,  writing on the board, demonstration of programmes/scripts

**Reading List:**

**Responsible for Module:**
Kainz, Josef; 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

## CS0170: Advanced Modelling and Optimization | Advanced Modelling and Optimization

Version of module description: Gültig ab winterterm 2021/22

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>German/English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>7 | **Total Hours:**<br>210 | **Self-study Hours:**<br>150 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
The examination is based on two project works (each 50% of evaluation).

The project works examine the understanding of the modeling and programming techniques discussed in the course. The project works includes, appling algorithms to solve problems, creating mathematical models for examplary problems, and discuss presented results. By this the students have to demonstrate that they have understood and can apply the mathematical models and methods to solve planning problems. The project paper serves the assessment of the understanding of the modeling and programming language.

For the project paper the participants get a randomly assigned fictive, extensive decision problem. For this problem, the following has to be prepared:
- a modeling of the problem as a mathematical program, as well as explanation of the program
- an implementation of the program in a known optimization and programming language
- a verbal and graphical explanation of the of the results for the original problem

The grading of the project paper is done by the following criteria:
- Correctness of modeling and implementation as well as of the results (60% of examination)
- Clarity, comprehensibility and efficiency of the implementation (30% of evaluation)
- correct language, typesetting and outer form of the paper (10% of evaluation)

**Repeat Examination:**
End of Semester

**(Recommended) Prerequisites:**
Operations Research (CS0098)

**Content:**
This course is about modeling, solving and analyzing planning and decision problems using mathematial concepts. The course teaches the basics of linear, discrete and dynamic optimization. In addition, there is an introduction to optimization and corresponding programming languages, as well as teaching methods for analyzing and structuring algorithms, designing suitable object-oriented data structures, applying known standard algorithms and connecting them to other resources and programming environments.

**Intended Learning Outcomes:**
After successful completion of the module students are capable of modelling planning problems. Students learn to model real life business problems by applying mathematical programming techniques. They can independently implement mathematical models by using an optimization language and heuristical approaches. They are able to solve the models within the scope of a case study and can interpret the results. Furthermore, they deepen their knowledge in several different modeling techniques and basics of object oriented programming.

**Teaching and Learning Methods:**
The module consists of a lecture and exercise courses, which are provided weekly. In the lecture the content is jointly developed with the students mainly by using slides. The exercise course repeats parts of the lecture contents by using examples and offering the opportunitis to implement poblems individually. The excercises give the student the opportunity to pose questions and receive immediately help from the teaching assistant.

**Media:**
Script, Presentation slides

**Reading List:**
Hilier, F. and Lieberman, G., Introduction to Operations Research, McGraw-Hill, 2009
Popp, Andreas: Modellierung und Optimierung mit OPL. epubli, 2015
Schildt, H.: Java, A Beginner's Guide, 5th Edition, McGraw-hill, 2011
Winston, W.: Operations Research - Applications and Algorithms. 4th ed. (internat. student ed.), Belmont, Calif. (Duxbury), 2004.

**Responsible for Module:**
Alexander Hübner alexander.huebner@tum.de

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

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

## Module Description

### CS0255: Current Topics in Machine Learning and Bioinformatics | Current Topics in Machine Learning and Bioinformatics [CTMLBI]

Version of module description: Gültig ab summerterm 2023

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|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter/summer semester |
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>60 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
The learning outcomes are tested by a graded seminar presentation with a duration of approximately 45 minutes including a discussion with the audience. The seminar allows the students to assess the extent to which they can summarize a complex scientific work in the field of Machine Learning or Bioinformatics correctly and present it to an audience in a comprehensible and convincing way. Furthermore, to assess the skill to quickly understand, review and critically discuss recent research in these fields, the active participation and discussions of the other seminar presentations will be considered as well.

**Repeat Examination:**

**(Recommended) Prerequisites:**
Knowledge in Machine Learning and Bioinformatics (e.g. Bioinformatics (WZ1631) and Artificial Intelligence for Biotechnology (CS0012)) is expected

**Content:**
At the beginning of this course, introductory lectures about current topics in Machine Learning and Bioinformatics will be given. The following topics are treated exemplarily:
- Ensemble learners
- Neural Networks (Basic concept, Feedforward neural networks, Recurrent Neural Networks, Convolutional Neural Networks, Generative Models)
- Green Artificial Intelligence
- Genome-wide Association Studies
- Phenotype Prediction
- Protein-Protein Interaction Network Analysis
- Protein Prediction

- Data Driven Biotechnology
In this course, we will also talk about recent Machine Learning and Bioinformatics research and how it can support sustainability, e.g., by guiding downstream research with data-driven approaches. Furthermore, we will also look at Green Artificial Intelligence, a research direction that aims to make resource-intense AI development more sustainable. After introductory lectures, each student will analyze a recent scientific paper in these research areas in self-study and present it to the course. Active participation and discussions in all the other presentations is expected.

**Intended Learning Outcomes:**
After successful participation in this module, students will be able to understand and present recent research in Machine Learning or Bioinformatics. They are enabled to analyze recent scientific publications in one of the two fields. Based on this knowledge, they can summarize and present a scientific paper in a concise and understandable way as well as to discuss recent research in Machine Learning or Bioinformatics. Furthermore, students know about current research directions in these scientific fields and know how current Machine Learning and Bioinformatics research supports sustainability.

**Teaching and Learning Methods:**
At the beginning of this course, introductory lectures to current Machine Learning and Bioinformatics topics will provide additional and necessary fundamentals to understand recent scientific publications. Furthermore, each student will analyze a recent research paper in one of the two fields in self-study and present it to the course to train the ability to understand advanced concepts. Beyond that, for further training of these skills, the paper presentations will be discussed in the course.

**Media:**
Slide presentation, blackboard, discussion forums in e-learning platforms

**Reading List:**
Pattern Recognition and Machine Learning, Christopher M. Bishop
Deep Learning, Ian Goodfellow, Yoshua Bengio, Aaron Courville

**Responsible for Module:**
Prof. Dr. Dominik Grimm, Florian Haselbeck

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

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

# Module Description

## CS0260: Energy and Economics | Energy and Economics [EUW]

Version of module description: Gültig ab summerterm 2022

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

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

**Description of Examination Method:**
The examination will take the form of a written test (60 minutes). The students prove that they can understand and answer questions and the connections between the energy conversion, the conversion of renewable raw materials, the energy supply in general and the current energy-political and economic situation. Group work can be included and be part of the exam.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Prior participation and passing of the fundamentals of Thermodynamics module is required for participation in the Energy and Economics module.

**Content:**
The module deals with the basics of energy sources, climate change and the technology of the heat, electricity and fuel market and the use of renewable raw materials, including an introduction to simple technical systems and current topics on the energy industry. It also deals with electricity trading, $CO_2$ trading and the current situation of various energy technologies.
In exercises small examples are calculated to the economy (production costs of heat and power of plants (e.g. combined heat and power plants).

**Intended Learning Outcomes:**
By participating in the module, students will be able to understand the energy sources and simple principles of energy conversion into heat and electricity. They can perform simple economic assessments of energy systems and understand related market mechanisms of the electricity and heat market.

**Teaching and Learning Methods:**
The module consists of a lecture with exercises. The contents of the lecture are conveyed in the lecture and through presentations.

**Media:**
Presentations, exercise

**Reading List:**
Kaltschmitt, M.; Hartmann, H.; Hofbauer, H.: Energie aus Biomasse, 2. Auflage, Springer, ISBN 978-3-540-85094-6, 2009
Karl, J.: Dezentrale Energiesysteme, Oldenbourg, ISBN 3-486-27505-4, 2004/

**Responsible for Module:**
Gaderer, Matthias; 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

### CS0261: Phytopharmaceuticals and Natural Products | Phytopharmaceuticals and Natural Products [Phytopharm]

Version of module description: Gültig ab summerterm 2022

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
Knowledge of the covered topics of phytopharmaceuticals and natural products compounds is assessed in a written examination (90 minutes).  In addition, students are required to explain the medicinal effects of medicinal plants in the examination using examples.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Organic and anorganic chemistry, botany

**Content:**
Content of the lecture:
-definition of medicinal plants and phytopharmaceuticals
-position of phytopharmaceuticals in pharmacology
-compounding (tea drugs, soluble extracts, sCO2 extracts, steam destillation, pure substances)
-effect-determining components and frequent mechanisms (inflammation cascade, infections, coagulation system, neurotransmission, digestive system)
-typical medicinal plants grown in Europe
-international trade in medicinal plants
-important classes of compounds (terpenes, steroids, coumarine, alcaloids, vitamins, saccharides)
-quality determination and typical methods (chromatography)
-falsification and chemotype (chemical race)
-drug regulator affairs (authorisation, documents)
-use of medicinal plants in practice

**Intended Learning Outcomes:**
After their participation, students can explain the production of phytopharmaceuticals derived from typical medicinal plants (from collection to quality control). They can relate chemical compounds and medical effects of typical examples.

**Teaching and Learning Methods:**
The lecture takes the form of oral presentation given by teaching staff with the help of PowerPoint media, books and other written material.

**Media:**
PowerPoint presentation and printed handout. Laboratory equipment for experiments.

**Reading List:**
Deutschmann, F., Hohmann, B., Sprecher, E., Stahl, E., Pharmazeutische Biologie, 3 Bde., G. Fischer Verlag, 1992

**Responsible for Module:**
Riepl, Herbert; 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

## CS0263: Geothermal Energy Systems | Geothermal Energy Systems [GeoE]

*Potentials of geothermal energy supply*

Version of module description: Gültig ab winterterm 2022/23

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
Students demonstrate their knowledge and understanding of geothermal systems and their potential for energy supply in form of a written examination (90 minutes). Students deliver definitions, describe and outline relevant processes for the geothermal energy supply. Furthermore, students calculate different technical specifications and parameters based on provided practice-oriented examples.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Successful completion of the module "Basics in engineering" and "Introduction to Energy conversion and Energy economy". Knowledge and interest in Geology and Physics are valuable.

**Content:**
The course focuses on the variety of options for geothermal energy supply. This includes an introduction to relevant geological expert knowledge such as formation of the earth, earth's structure, geothermal heat sources, the rock-cycle as well as mechanism of subsurface heat transport. After an introduction to deep geothermal exploration (drilling, drilling technology and related risks) the focus of the course is placed on shallow geothermal energy and use of ground-coupled heat pump systems.

This includes the design and working principle of a heat pump system and its integration in technical building equipment as well as the analysis of their ecological and economic sustainable operation on living quarter scale. The analysis is also done with regards to existing technical guidelines as well as legal boundary conditions. Practice-oriented tasks will be used to

demonstrate and critically evaluate the basic planning steps of heat pump systems and obtaining the relevant parameters. Existing and innovative geothermal exploration concepts will be analyzed and discussed against this background.

**Intended Learning Outcomes:**
After successful completion of the module, students acquire in-depth understanding of geothermal energy systems including relevant geological and hydrogeological processes. Students can evaluate the ecological as well as economic sustainability of geothermal heat source systems. They can test plausibility of dimensioning ground-coupled heat pump systems and understand, explain and comprehend heat transport processes and regeneration processes within the subsurface.

Students prepare short, practice-oriented tasks as homework in a project team (group work). Thereby, they acquire the ability to view and assess information within a limited period of time and solve practice-oriented questions. The edited information and results are passed on to the other participants accordingly with the focus on sharing results in the form of a written report as well as team work.

**Teaching and Learning Methods:**
The content is taught in lectures and presentations and strengthened by case studies and exercises. If applicable, the module is complemented by an excursion.

**Media:**
Lecture, Power Point presentation, blackboard, case examples, topics prepared and presented by participants.

**Reading List:**
Bayerisches Staatsministerium für Landesentwicklung und Umweltfragen (2005): Oberflächennahe Geothermie.
Bauer, M., Freeden, W., Jacobi, H., Neu, Th. (Hrsg.) (2018): Handbuch Oberflächennahe Geothermie. Springer Spektrum, 1. Auflage.
Stober, I. & Bucher, K. (2014): Geothermal Energy. Springer Spektrum, 1st edition.
Hölting, B., Coldewey, W.G. (2013): Hydrogeologie. Springer Spektrum, 8. überarbeitete Auflage.
Dassargues, A. (2018): Hydrogeology: Groundwater Science and Engineering, CRC Press, 1st edition.
Grotzinger, T. & Jordan, T. (2017): Press/Siever Allgemeine Geologie. Springer Spektrum, 7. Auflage
Grotzinger, T. & Jordan, T. (2014): Understanding Earth. W.H. Freeman & Company, 7th edition

**Responsible for Module:**
Vienken, Thomas; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Geothermal Energy Systems (Vorlesung mit integrierten Übungen, 4 SWS)

Vienken T [L], Vienken T
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0264: Polymer Processing | Polymer Processing [PolyProc]

*Processing of polymers intro plastic parts*

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
The content and learning objectives of the lecture are examined at the end of the semester in a written test (90 min). An oral pre-test containing safety relevant laboratory work issues must be carried out before the individual pratical course. A written report on the practical course consisting of approximately five pages must be submitted. The written report is an ungraded student achievement.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Polymer chemistry, polymer physics, rheology fluid mechanics, Biogenic Polymers

**Content:**
The lecture deals with unit operations, basic techniques and processes of plastic material processing, e.g. compounding, extrusion, injection molding, plastic part forming processes and also typical applications. In addition, methods for characterizing thermal and mechanical properties are presented. One focus here is the connection between the processing parameters and the end-use properties. The acquired knowledge is deepened in the accompanying practical course. Injection molding and extrusion tests are carried out and the test specimens are then characterized with regard to their thermal, optical and mechanical properties. Additional foci will be laid on the chemistry, structure and classification of polymers and plastic parts. The lecture also deals with the physical properties of polymers and plastic materials involving materials science. Characterization of the mechanical and thermal properties and their effects on processing, viscosity, viscoelastic behavio will be discussed

**Intended Learning Outcomes:**
In addition to the chemical-physical basics of polymeric materials, this module imparts the methodical knowledge about classic and modern innovative processing methods of polymeric materials. The students are able to sensibly classify plastic materials, their manufacture and use them for specific applications. The basics for the production technology of plastic materials are acquired. After successfully completing the module, students are able to select and use methods for processing plastic. They will be able to assess sustainability aspects of the polymer production process in terms energy consumption and materials use. Through practical work, the competence for the meaningful use of testing and characterization methods of polymer materials is acquired.

**Teaching and Learning Methods:**
Lecture (lecture by teaching staff with Power Point slide media, books and other written material), laboratory practical course (experimentation of the students under supervision)

**Media:**
Power Point slide presentations; Drawing and writing on a black board; Laboratory equipment for experimentation

**Reading List:**
Polymer Engineering; Technologien und Praxis; Peter Eyerer, Peter Elsner, Thomas Hirth
Polymer Extrusion; Chris Rauwendaal
Extrusion: The Definitive Processing Guide and Handbook; Harold F. Giles, Jr.
Einführung in die Kunsstoffverarbeitung; Michaeli, W.
Werkstoffkunde der Kunststoffe; Menges, G.

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Polymer Processing (Practical) (Praktikum, 1 SWS)
Zollfrank C [L], Helberg J

Polymer Processing (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Helberg J
For further information in this module, please click campus.tum.de or here.

# Module Description

## CS0266: Sustainable Chemistry | Sustainable Chemistry

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
The examination will take the form of a written test (60 minutes). In this examination the competence for the evaluation of chemical processes and for the derivation of optimization strategies shall be proven. No aids are permitted in the written examination. In order to additionally check whether the students are able to communicate scientific topics in front of an audience and whether they are able to critically deal with problems in individual steps, the results of the processing of the case studies are presented in the form of a 20-minute presentation alone or in a group. This presentation is ungraded study achievement.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Successful participation in the module "Basics in chemistry" or comparable knowledge in chemistry.

**Content:**
The module teaches basic principles of sustainable chemistry. Focus is set on the evaluation of chemical processes in view of efficiency, atom economy and amount of waste. In addition, optimizsation strategies related to catalytical methods, raw material and energy efficiency are discussed. Students individually prepare current topics related to sustainable chemistry and present them in the seminar.

**Intended Learning Outcomes:**
By attending the module events, students are able to highlight the principles of sustainable chemistry. Students can analyze the efficiency and waste quantities of chemical reactions and evaluate various alternative processes. Furthermore, they are able to discuss further chemical aspects of the conversion of renewable raw materials into valuable products. Through the

independent development of case studies, the students master all the steps that are important in the critical examination of problems (consideration of the example, development of criteria for evaluation, assessment, presentation of the results to an audience).

**Teaching and Learning Methods:**
Lecture with board addresses and presentations: Basic development and derivation of technical contents; seminar with written tasks. Consolidation of the technical learning contents through learning activity of the students themselves, e.g. through independent development of case studies from the field of sustainable chemistry.

**Media:**
Presentation, script, examples

**Reading List:**
Stanley E. Manahan: Green Chemistry, ISBN: 0-9749522-4-9

**Responsible for Module:**
Zollfrank, Cordt; Prof. Dr. rer. silv.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Sustainable Chemistry (Seminar) (Seminar, 1 SWS)
Zollfrank C [L], Helberg J, Zollfrank C
For further information in this module, please click campus.tum.de or here.

## Module Description

### CS0267: Biological Materials | Biological Materials

Version of module description: Gültig ab winterterm 2023/24

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

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

**Description of Examination Method:**
Understanding of the course contents and their application will be tested in a written exam of 90 minutes duration. In detail, the students are required to describe the physical and chemical foundations of the formation, as well as relations between the hierarchical structure and properties, of typical biological materials. Further, the transfer of this knowledge to technological applications and to the design of novel biologically inspired materials, as covered in the course, is a test subject. Lecture notes are not permitted.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge in geometry and chemistry

**Content:**
The module Biological Materials in Nature and Technology covers important biological functional materials, based on basic materials scientific knowledge. This encompasses such materials that fulfill, in their biological system, or in a technological application, either in native state, or modified, one or more specific functions. Differences and similarities to classical engineering materials are pointed out. In addition to the modules Bioinspired Materials and Instrumental Analysis, the students learn important methods for structural and property analysis. After a presentation of the classification of biological materials, students- are taught the basic correlations between hierarchical structuring and macroscopic properties. As the most important complex, the influence of hierarchical structuring on the mechanical properties of materials will be discussed. The students learn, which modes of failure can occur in biological systems and how they are influenced. In this context, modification routes for biological materials are shown and discussed.

**Intended Learning Outcomes:**
After successful completion of the module, the students are enabled to name criteria for a proper usage of biological materials. They can name specialized methods for the analysis of hierarchical structures and the derived material properties and explain the correlations between structure and external properties. Further, they are able to describe tailored modification routes for biological materials.

**Teaching and Learning Methods:**
Lecture with discussion and case studies

**Media:**
Presentation, slides

**Reading List:**
Structural Biological Materials: Design and Structure-Property Relationships. Eds Elices M, Pergamon-Elsevier Science Ltd, Oxford, (2000).
Fratzl P & Harrington MJ. Introduction to Biological Materials Science. Wiley VCH, Weinheim, Germany, (2015).

**Responsible for Module:**
Van Opdenbosch, Daniel; 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.

## Electives TUM (max. 18 ECTS) | Electives TUM (max. 18 ECTS)

## Module Description

## WZ4202: Political and Social Perspectives of Renewable Resources | Political and Social Perspectives of Renewable Resources

Version of module description: Gültig ab winterterm 2015/16

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>105 | **Contact Hours:**<br>45 |

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

**Description of Examination Method:**
Oral presentation of the group project work, review paper for a scientific journal. The learning outcomes are assessed by a group project work concerning a selected topic related to the political and social perspectives of renewable resources. Therefore students have to prepare a scientific paper for an international journal of their choice and give a short oral presentation about the work done for the paper, similar to what would be expected in a 15 minute conference presentation.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Knowledge of sustainable resources (materials and energy). Scientific writing.

**Content:**
In the lectures a number of examples of societal aspects of Sustainable Resource programs will be presented and discussed. Backgrounds are global developments such as urbanization, the rise of countries like China and India, resource availability and technological developments. Case studies deal with tropical forestry and pros and cons of tropical hardwood uses, urban planning, vernacular architecture and the use of renewable resources We take a tour around the world and look at social housing programs in Europe, Brazil and South-East Asia. Furthermore we look at successes and failures in the German/European energy policies in comparison to the United States.

**Intended Learning Outcomes:**
After this course, students should be able to:

1. Develop SR stimulation programs on country or regional level and priority analysis of renewable resource applications
2. Assess priorities for development and application of renewable resources in countries with different levels of development
3. Critically analyze existing SR programs taking into account social values of stakeholders,
4. Assess impacts of global developments such as urbanization and UN-policies on SR.

**Teaching and Learning Methods:**
Discussion and creativity sessions. Project work evolving in a scientific paper for a journal of choice. Oral presentation.

**Media:**
Lectures, UN-policy notes, Discussion and Creativity sessions.

**Reading List:**
Tba

**Responsible for Module:**
van de Kuilen, Jan Willem; Prof. Dr.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Political and Social Perspectives of Renewable Resources (Vorlesung, 4 SWS)
van de Kuilen J [L], van de Kuilen J, Khaloian Sarnaghi A
For further information in this module, please click campus.tum.de or here.

# Module Description

## BV460017: Hydro Power und Energy Storage | Wasserkraft und Energiespeicherung

Version of module description: Gültig ab winterterm 2022/23

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>winter semester |
| **Credits:***<br>3 | **Total Hours:**<br>90 | **Self-study Hours:**<br>60 | **Contact Hours:**<br>30 |

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

**Description of Examination Method:**
The module examination is a written exam (60 minutes, open book, allowed tools: notes, print medias (books, printed slides…), non-programmable calculator; not allowed tools: technical devices, communication). It consists of theoretical questions and practical calculations, each about 50%.

Furthermore, they prove that they can design a water power station in concept and dimensioning as well as the state-of-the-art technologies for energy storage.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Bachelor's level knowledge in hydraulic engineering, e.g.
• "Basic Module Hydraulic and Water Resources Engineering"
• "Supplementary Module Hydraulic and Water Resources Engineering"

**Content:**
The module provides in-depth knowledge of principles, methods and technologies for calculation and management of sustainable generation of energy from hydropower.

• types of hydro power stations, specific requirements of large and small hydro power
• elements of hydro power installations
• hydro turbines: turbine types, application ranges
• stream turbines: fundamentals, turbine types, application range
• energy conversion in hydro turbines - physical fundamentals

• planning of hydro power stations: hydrological surveys, layout, power plan
• needs and requirements for energy storage
• fundamental options for power storage
• properties of storage technologies, pros and cons, application ranges, potential, development state, project examples
• pumped storage plants: fundamentals, electromechanical equipment, new approaches

**Intended Learning Outcomes:**
After successful participation in the module, students will be able
• to describe, identify and assess established and newly proposed technologies of hydropower and energy storage
• to explain and assess the physical foundations of the energy conversion as well as the fundamental approach in planning hydropower projects
• to evaluate hydropower project plans and to perform planning themselves.

**Teaching and Learning Methods:**
• lecture style
• practical examples
• coordinated moodle tests (voluntary)

**Media:**
• PowerPoint presentations with film sequences and computer animations
• blackboard exercises
• moodle tests (voluntary)
• lecture notes in moodle

**Reading List:**
See lecture notes

**Responsible for Module:**
Prof. Dr. Nils Rüther (nils.ruether@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**
Hydro Power and Energy Storage (Vorlesung, 2 SWS)
Rüther N
For further information in this module, please click campus.tum.de or here.

## Module Description

### ED150010: Sustainable Mobile Drivetrains | Nachhaltige Mobile Antriebssysteme

Version of module description: Gültig ab winterterm 2022/23

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

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

**Description of Examination Method:**
Die Modulprüfung erfolgt in Form einer schriftlichen Klausur (Prüfungsdauer: 90 min). Die Studierenden sollen in begrenzter Zeit die Konzepte nachhaltiger mobiler Antriebssysteme auf verschiedene Frage- und Problemstellungen anwenden. Damit soll z. B. überprüft werden, ob die Studierenden bewerten können, wie eine konkrete Ausgestaltung eines Antriebssystems in verschiedensten Fortbewegungsmitteln ausgeführt werden kann oder ob die Studierenden die Grundlagen der Funktionsweise und des Aufbaus von Kolbenmotoren, elektrischen Antriebssträngen und von Antriebssträngen mit Brennstoffzelle verstehen.
Als Hilfsmittel zugelassen sind: Schreibutensilien, Lineal und ein nicht programmierbarer Taschenrechner.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
None

**Content:**
Themenschwerpunkte:
* Nachhaltigkeit und Klimaschutz
* Gestaltung nachhaltiger Mobilität
* Grundlagen der Fahrzeugtechnik
* Grundlagen der Fahrzeugantriebe
* Verbrennungsmotoren mit nachhaltigen Kraftstoffen
* Elektrische Antriebssysteme (Batterie, Inverter, e-Motor)
* Antriebssysteme mit Brennstoffzellen
* Energie und Mobilität

**Intended Learning Outcomes:**
Nach erfolgreicher Teilnahme am Modul "Nachhaltige Mobile Antriebssysteme" sind die Studierenden in der Lage...
... zu verstehen, wie und warum der Klimawandel eine Transformation hin zu nachhaltiger Mobilität erfordert
... einzuordnen, wie sich diese Transformation auf die traditionellen Verkehrsmittel und ihre Antriebe auswirken wird
... zu bewerten, wie eine konkrete Ausgestaltung eines Antriebssystems in verschiedensten Fortbewegungsmitteln ausgeführt werden kann
... die wichtigsten mobilen Antriebssysteme nach ihren jeweiligen Vorteilen, Nachteilen und Einsatzgebieten zu beurteilen
... die Grundlagen der Funktionsweise und des Aufbaus von Kolbenmotoren zu verstehen
... die Grundlagen der Funktionsweise und des Aufbaus elektrischer Antriebsstränge zu verstehen
... die Grundlagen der Funktionsweise und des Aufbaus von Antriebssträngen mit Brennstoffzelle zu verstehen
... einzuordnen, welches Antriebssystem für eine gegebene Anwendung am besten geeignet ist
... zu bewerten, welchen Einfluss die Rolle des Energieträgers auf die Nachhaltigkeit des gesamten Antriebssystems ausübt
... grundlegende Zusammenhänge zwischen Energie, Mobilität und Antriebssystem kritisch zu hinterfragen
... einfache aber wirkungsvolle Grobabschätzungen der wichtigsten Eigenschaften moderner Antriebssysteme vorzunehmen

**Teaching and Learning Methods:**
In der Vorlesung werden die Grundlagen nachhaltiger mobiler Antriebssysteme anhand von Vortrag, Präsentation und Tablet-PC vermittelt. Die Theorie wird durch Anwendungsfälle erläutert und mit Hilfe von einfachen Rechenbeispielen gefestigt. Erfahrungen und Probleme aus der Praxis werden vorgestellt, diskutiert und gerechnet.
Damit sollen die Studierenden beispielsweise lernen, zu bewerten, wie eine konkrete Ausgestaltung eines Antriebssystems in verschiedensten Fortbewegungsmitteln ausgeführt werden kann sowie die Grundlagen der Funktionsweise und des Aufbaus von Kolbenmotoren, elektrischer Antriebsstränge und von Antriebssträngen mit Brennstoffzelle zu verstehen.
Alle Lehrmaterialien sowie weiterführende Informationen werden kostenfrei in der Vorlesung verteilt oder werden online zur Verfügung gestellt. Sprechstunden werden flexibel angeboten.

**Media:**
* Vortrag
* Präsentation
* Tablet-PC mit Beamer
* Online-Lehrmaterialien

**Reading List:**
Zapf, Martin: Kosteneffiziente und nachhaltige Automobile. 2. Auflage. Wiesbaden: Springer Vieweg, 2021.

Doppelbauer, Martin: Grundlagen der Elektromobilität. Wiesbaden: Springer Vieweg, 2020.
Schreiner, Klaus: Verbrennungsmotor - kurz und bündig. Wiesbaden: Springer Vieweg, 2017.
Klell, Manfred: Wasserstoff in der Fahrzeugtechnik. 4. Auflage. Wiesbaden: Springer Vieweg, 2018.

**Responsible for Module:**
Jaensch, Malte; Prof. Ph.D.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Nachhaltige Mobile Antriebssysteme [ED150010] (Vorlesung, 3 SWS)
Jaensch M [L], Jaensch M, Heindl J
For further information in this module, please click campus.tum.de or here.

# Module Description

## ED160007: Lithium-Ion Battery Production | Lithium-Ionen-Batterieproduktion [VLBP]

*Lithium-ion battery production*

Version of module description: Gültig ab winterterm 2021/22

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

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

**Description of Examination Method:**
The module examination takes place in the form of a written exam (examination duration 90 minutes). By means of comprehension questions, calculation tasks and transfer tasks, the students should prove that they have an understanding of the basic processes of lithium-ion battery production and that they can apply this understanding. The content of the exam consists of comprehension questions from the lecture as well as various tasks, some of which are more advanced, based on the content of the exercises accompanying the lecture. Only a non-programmable calculator is allowed as an aid.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Prior experience in electrical energy storage and production engineering is recommended. Prior knowledge in chemistry and process engineering is not required but helpful.

**Content:**
The lecture provides an insight into all process steps in the production of lithium-ion batteries. The focus is on the holistic view of the process chain, including important process parameters and influencing factors.
Detailed content:
- Structure of the lithium-ion cell, electrochemical and electro-technical fundamentals, energy storage methods
- Material and cell systems on component level, process chains of battery production, safety aspects, production environment
- Mixing processes for anodes and cathodes (stirring, mixing)

- Coating processes for anodes and cathodes (slot die, doctor blade, cascade die) and process variants
- Calendering processes (porosity analysis, defect patterns)
- Packaging and assembling (cell formats, application areas)
- Packaging and contacting (ultrasonic welding, friction stir welding, laser welding)
- Filling and wetting (electrolyte properties, electrochemical impedance spectroscopy)
- Formation and aging (passivation layer, charge/discharge rate and lifetime test)
- Electrochemical characterization, cost models, quality criteria
- Recycling (material recycling, second life of the battery cell)
- Innovative process steps (laser patterning, mechanical prelithiation) and alternative lithium-ion battery technologies (solid-state batteries, sodium-ion battery)

**Intended Learning Outcomes:**
After participating in the module, students will be able to understand basic interrelationships of lithium-ion battery production and to evaluate them.
After successful participation in the module, students will be able to:
- Demonstrate a basic understanding of the material systems processed
- Evaluate the mode of operation of a lithium-ion battery on the basis of measurement characteristics
- Know, analyze and classify all process steps in lithium-ion battery production and their variants
- Understand basic interrelationships in lithium-ion battery production
- To develop requirements for the respective processes and suitable plant technology
- Evaluate typical fault patterns and assess their possible causes and consequences for the product
- Characterize the properties of a battery cell using cell tests and correlate them with the manufacturing processes
- Know, understand and apply important methods of quality assurance
- Understand future technologies and their special features with regard to the product and be able to recognize and classify trends

**Teaching and Learning Methods:**
In the lecture, the theoretical basics of lithium-ion battery production are taught by means of lecture and presentation. With the explanations from the lecture and corresponding self-study, the students learn to understand, evaluate and develop all process steps of lithium-ion battery production. Students supplement the course material by studying the recommended literature on battery production and related areas.
Students independently solve questions and tasks related to the content of the course using practical examples. In the exercise, sample tasks are calculated, discussed and debated together with the students. This is intended to ensure that the students can independently acquire the learning outcomes and transfer performance.

**Media:**
Presentations, videos and other illustrative material are used for visualization. Via the eLearning portal, the participants receive all exercise documents for preparation, which are then discussed

in the exercises. Furthermore, the lecture materials from the lecture are made available to the participants.

**Reading List:**
Recommended basic literature:
Korthauer, Reiner (Hrsg.): Handbuch Lithium-Ionen-Batterien. Springer-Verlag Berlin Heidelberg 2013. ISBN: 978-3-642-30653-2
Gulbinska, Malgorzata K. (Hrsg.): Lithium-ion Battery Materials and Engineering. Springer-Verlag 2014. ISBN: 1447165470
Julien, Christian (Hrsg.): Lithium Batteries, Science and Technology. Springer International Publishing 2015. ISBN: 9783319191089

In addition, further literature references are recommended in the individual lectures for in-depth study.

**Responsible for Module:**
Daub, Rüdiger; Prof. Dr.-Ing.

**Courses (Type of course, Weekly hours per semester), Instructor:**
Lithium-Ionen-Batterieproduktion (Vorlesung, 2 SWS)
Daub R [L], Daub R, Jaimez Farnham E, Lindenblatt J

Lithium-Ionen-Batterieproduktion (Übung, 1 SWS)
Daub R [L], Daub R, Lindenblatt J
For further information in this module, please click campus.tum.de or here.

# Module Description

## MW2245: Think. Make. Start. | Think. Make. Start. [TMS]

*Build innovative products of your ideas in 10 days!*

Version of module description: Gültig ab winterterm 2024/25

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

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

**Description of Examination Method:**
The module examination consists of a project work incl. written documentation (approx. 10 pages) and presentation (10 min), in which the students develop a new product in a group project and present their idea for founding a company on this basis. The individual performance is assessed to what extent the students are able to develop a product with market potential by means of an iterative approach to prototypical implementation. The assessment also includes the ability to work in a team, the ability to make well-founded design decisions and the completeness and conclusiveness of the concept, taking into account social relevance, novelty and innovation. As part of the project work, in addition to documentation, there is a final oral presentation. Through the presentation, students are expected to show whether they can demonstrate their ability to act as a competent team.

**Repeat Examination:**

**(Recommended) Prerequisites:**
The basic requirement is a willingness to engage with new learning methods, approaches, disciplines and ways of working. Cross-role experience in project management, product development (Design Thinking, TRIZ, Systems Engineering, etc), interdisciplinary teamwork, communication skills, creativity and problem solving skills are an advantage. A lot of emphasis is placed on practical experience.

For the "Problem Expert" role, experience in the following areas is an advantage:
- User Testing, Requirements Engineering, Interviewing, Human-Centered Design, Design, Visualisation, Use Case Definition, UX/UI Design, marketing, market research, benchmarking, design thinking.

For the "Tech Developer" role, experience in the following areas is an advantage:
- Hardware (mechanical): design, manufacturing (workshop/makerspace), prototyping, CAD/CAM.
- Hardware (electronic): embedded systems engineering, microcontrollers, sensors/actuators, Arduino, Raspberry, circuitry, board design, metrology, BUS protocols, prototyping, closed-loop/open-loop control, robotics
- Software focus: Backend development, databases, frontend development, machine learning, web development, app development, embedded systems

For the "Business Developer" role, experience in the following areas is an advantage:
- Business Plan/Strategy/Design, Marketing, Sales, Interviewing, Finance & Accounting, Business Law & Regulations, Entrepreneurship.

The number of participants is limited and there will be an application process.

**Content:**
During the interdisciplinary team project, students work methodically, purposefully and agilely on a development project to develop innovative new products with the intention of successfully launching them on the market. Current needs and problems from social, technological and economic systems are identified, analysed and validated in the interdisciplinary team. In doing so, they cooperatively solve challenges that arise from constraints from the different disciplines. They generate suitable market hypotheses and product ideas at an early stage and interact with initial potential customers/users. They iteratively create prototypes and evaluate their hypotheses with them in experiments.

For more information, visit www.thinkmakestart.com and www.tms.tum.de.

**Intended Learning Outcomes:**
After participating in the module “Think.Make.Start.” the students are able to
- reproduce the principles of user-centered design
- apply methods of product development (e.g., Design Thinking) to a challenge of their choice
- develop important hypotheses involving relevant stakeholders (customer, user, ...) through proper planning with "purposeful prototyping"
- examine the relevance of a problem and develop a solution collaboratively in an interdisciplinary team
- design a prototype based on the acquired design methods and analyzed insights
- lay the foundation for one's own business start-up by identifying a start-up idea or team.

**Teaching and Learning Methods:**
"THINK. MAKE. START." is a two-week, practice-oriented, interdisciplinary and competitive teaching format in which students from all faculties can participate (credits are given individually related to the study program). It is organised by the different chairs of TUM, TUM ForTe, and UnternehmerTUM. They get access to the high-tech workshop Makerspace and budget to transform their own ideas into real prototypes (mechatronic products). Learning outcomes are achieved through the following teaching and learning methods:

- Milestones to be achieved, team roles to be held and predetermined course structure provide the roadmap for the project.
- Coaching and teaching expertise in prototyping, business validation, agile development, design thinking, systems engineering, lean startup and user-centred design.
- Teaching the basics of interdisciplinary collaboration through a role concept (Business Developer, Tech Developer, Problem Expert).
- All participants work in interdisciplinary teams (10 teams of 5 students each) and are encouraged to become active themselves and learn through practical experience (hands-on learning).
- Each team pursues a real business idea chosen for the seminar. Special attention is given to really understanding the customer and verifying the solution approach, through questioning, observation, prototyping or expert discussion.
- Using prototyping to bridge the gap between thinking and doing.
- Reflecting on one's own results and approach supports project decisions.
- The teams present their projects to a jury on DemoDay and present the prototypically implemented product ideas to guests from industry, the start-up scene and research.

**Media:**
Project manual, presentations, hand-outs, posters, videos, examples.

**Reading List:**
Esch Franz-Rudolf (2012) Strategie und Technik der Markenführung, 7. Auflage, Vahlen

Faltin, Günter (2008): Kopf schlägt Kapital, Hanser

Halgrimsson (2012): Prototyping and Model Making for Product Design (2012)

Kalweit Andreas, Paul Christof, Peters Sascha, Wallbaum Reiner (2012) Handbuch für Technisches
Produktdesign, Material und Fertigung, Entscheidungsgrundlage für Designer und Ingenieure, 2. Auflage, Springer

Kelly, Tom (2016): The Art of Innovation

Lindemann, U (2007): Methodische Entwicklung technischer Produkte - Methoden flexibel und situationsgerecht anwenden. 2. Auflage

Münchener Business Plan Wettbewerb: Handbuch Businessplan-Erstellung, München
http://www.evobis.de/coaching/handbuch/

Malek, Miroslaw / Ibach, Peter K. (2004): Entrepreneurship, Dpunkt Verlag

Moore, Geoffrey A. (2002): Crossing the Chasm, Harpercollins

Osterwalder, Alexander / Pigneur, Yves (2010): Business Model Generation: A Handbook for

Ries, Eric (2011): The Lean Startup

Savoia, Antonio (2019): The right It

Timmons, Jeffry A. / Spinelli, Stephen (2009): New Venture Creation, 7thedition, McGraw, Hill Professional

UnternehmerTUM (2011): Handbuch Schlüsselkompetenzen, 7. Auflage

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

**Courses (Type of course, Weekly hours per semester), Instructor:**
Think.Make.Start. (Praktikum, 4 SWS)
Zimmermann M [L], Tong Y, Hohnbaum K, Amm M, Büchner B, Baur C, Bien S, Mogk J
For further information in this module, please click campus.tum.de or here.

# Module Description

## WZ1590: Climate Change Economics | Climate Change Economics

Version of module description: Gültig ab summerterm 2024

| | | | |
|---|---|---|---|
| **Module Level:**<br>Master | **Language:**<br>English | **Duration:**<br>one semester | **Frequency:**<br>summer semester |
| **Credits:***<br>5 | **Total Hours:**<br>150 | **Self-study Hours:**<br>90 | **Contact Hours:**<br>60 |

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

**Description of Examination Method:**
There will be a written exam (Klausur) of 90 minutes at the end of the semester. The students will be asked to demonstrate, within the stipulated amount of time using predefined methods and resources, their ability to outline the challenges climate change poses to regulators, propose pragmatic solutions and strategies as well as ways of implementing them. This will be based on the competencies acquired from the relevant literature of economic modeling, theories of climate change, and their understanding of the course content. The written exam is an appropriate assessment method to evaluate the degree to which the students understand the theoretical framework of climate change implications as well as provides an opportunity for them to put forward arguments based on existing theory.

In addition, there is the option of taking a voluntary mid-term assignments as course work in accordance with APSO §6, 5. For this, a presentation (15 min) has to be given.
The module grade can be improved by 0.3 by passing the course work if this better characterises the student's performance level on the basis of the overall impression and the deviation has no influence on passing the examination. No repeat date is offered for the mid-term performance.
When retaking a failed module examination at the next possible examination date, successfully passed mid-term assignments will be taken into account.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
Basic knowledge:
• Micro Economics (Welfare Economics)
• Environmental Economics
• Resource Economics

**Content:**
This course covers the trends in current and future climate change and their effects on economic and social outcomes.

The lectures cover the following topics:
1. Introduction to the Basic Science of Climate Change
- The students will learn about the scientific themes of global climate change and the economic dimension of the phenomenon.
2. Basic Economics
- The students will learn how a market economy can be efficient and socially optimal as well as about the prospects of externality.
3. Optimal Emission Levels
- The students will learn of the optimal abatement path and its uncertainty with respect to damages as well as Integrated Assessment Models (IAMs).
4. Intra-generational equity in climate policy
- The students will learn about how to account for equity across space (intergenerational equity) when deriving optimal emission levels.
5. International Environmental Agreements
- The students will learn about the dynamics behind common strategies towards achieving some form of optimal emission level.
6. Policy Instruments
- The students will learn about diverse instruments such as quality-based approach and Pigouvian Tax.
7. Regulation via Prices vs. Quantities
- The students will learn what circumstances will a regulator prefer prices over quantities and vice versa.
8. Credit-based Mechanisms
- The students will learn about how to deal with countries that do not want to commit but have a high potential for low-cost reductions.
9. German Climate Policy
- The students will learn about German Climate Action - strategies and policies
10. European Union Emission Trading Scheme - EU ETS

**Intended Learning Outcomes:**
After successfully completing the module, students are able to:
• Evaluate economic models related to climate change.
• Understand theoretical models of climate change regulations as well as policies that affect emission levels.
• Comprehend the complexity, uncertainty and possibilities associated with optimal emission level.
• Analyze appropriate instruments for emission levels that are efficient and cost-effective.
• Understand different forms of climate agreements and climate action strategies that are currently being implemented

**Teaching and Learning Methods:**
The course consists of lectures (2 SWS) and seminars (2 SWS). The lecture forms the basis for the subsequent discussion within the seminar on climate change issues from an economic perspective. The content of the module is expected to be transferred to the students in an interactive learning manner (including discussions in the lectures but especially intensive discussions in the seminar) where, among others, emission reduction instruments are scrutinized. This encourages the students to independently and self-reliantly study the literature guided by a structured framework.

**Media:**
PowerPoint, flipchart, internet portals, online reports etc.

**Reading List:**
Bréchet, T., & Eyckmans, J. (2009). Coalition theory and integrated assessment Modelling: Lessons for climate governance. Global Environmental Commons: Analytical and Political Challenges in Building Governance Mechanisms.
Rohling, M., & Ohndorf, M. (2012). Prices vs. quantities with fiscal cushioning. Resource and Energy Economics, 34(2), 169-187.
MacKenzie, I. A., & Ohndorf, M. (2012). Optimal monitoring of credit-based emissions trading under asymmetric information. Journal of regulatory economics, 42(2), 180-203.
Hake, J. F., Fischer, W., Venghaus, S., & Weckenbrock, C. (2015). The German Energiewende–history and status quo. Energy, 92, 532-546.
Climate Action Plan 2050 Principles and goals of the German government's climate policy. https://www.bmu.de
/fileadmin/Daten_BMU/Pools/Broschueren/klimaschutzplan_2050_en_bf.pdf
EU ETS Handbook. https://ec.europa.eu/clima/sites/clima/files/docs/ets_handbook_en.pdf

**Responsible for Module:**
Sauer, Johannes; Prof. Dr. agr.

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

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

# Master's Thesis | Master's Thesis

## Module Description

### CS0173: Master's Thesis | Master's Thesis [Master's Thesis]

*M.Sc. Sustainable Management and Technology*

Version of module description: Gültig ab summerterm 2021

| **Module Level:** Master | **Language:** German/English | **Duration:** one semester | **Frequency:** winter/summer semester |
|---|---|---|---|
| **Credits:*** 30 | **Total Hours:** 900 | **Self-study Hours:** 850 | **Contact Hours:** 50 |

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

**Description of Examination Method:**
The module examination is based on the preparation and positive evaluation of the Master's Thesis (depending on the topic, approximately 25 to 100 pages). The overall grade results from the grading of the Master's Thesis.

**Repeat Examination:**
Next semester

**(Recommended) Prerequisites:**
70 credits including all compulsory modules of the Master's program

**Content:**
Deepening the knowledge of current academic literature on a specific topic, which can be freely chosen from the Sustainable Management and Technlogy program in consultation with the supervisor. Increase knowledge of appropriate research methods, as well as gaining further experience in their application.

**Intended Learning Outcomes:**
After completing the module, students are able to derive complex issues from the field of sustainable management and technology and to work on them independently on the basis of suitable scientific methods. In doing so, they demonstrate their ability to think analytically and work scientifically on their own. They are able to present their results coherently, discuss them and draw conclusions from them.

**Teaching and Learning Methods:**
First, the topic is specified together with the supervisor and a research question for the Master's Thesis is developed. Within the framework of the Master's Thesis, the students work on this scientific question. Among other things, literature research, formal modeling and/or empirical methods are used. The actual teaching and learning methods depend on the respective research question are to be clarified with the supervisor in each individual case.

**Media:**
Academic literature, software and so on

**Reading List:**
in consultation with the supervisor

**Responsible for Module:**
Prof. Dr. Alexander Hübner

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

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

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