Module Catalog

*M.Sc. Bioeconomy*
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)
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**[20201] Bioeconomy | Bioeconomy**

**Compulsory Courses | Pflichtmodule**

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**Electives | Major Schwerpunkt**

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[CS0275] Economic Valuation of Consumer and Environmental (non-market) Goods | Economic Valuation of Consumer and Environmental (non-market) Goods

[CS0277] Sustainability and Risk Management | Sustainability and Risk Management

[CS0278] Sustainability and Innovation Management in an Industrial Context | Sustainability and Innovation Management in an Industrial Context


[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

Master's Thesis | Master's Thesis

Compulsory Courses | Pflichtmodule

Module Description


Version of module description: Gültig ab winterterm 2020/21

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<th>Module Level:</th>
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<td>Master</td>
<td>English</td>
<td>one semester</td>
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<tr>
<td>6</td>
<td>180</td>
<td>120</td>
<td>60</td>
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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. There will be two examinations: one written exam with a duration of 60 minutes (no additional tools allowed) and one oral presentation concerning a case-study with a duration of 20 minutes. The weighting factor of both examinations is 1:1.

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, Endogenous Switching Regression, 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 R or 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:**

**Responsible for Module:**
Anja Faße

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

Advanced Empirical Research Methods (Lecture) (Vorlesung, 2 SWS)
Faße A [L], Faße A, Ngassa C

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://campus.tum.de).
Module Description

CS0097: Advanced Environmental and Resource Economics | Advanced Environmental and Resource Economics

Version of module description: Gültig ab winterterm 2020/21

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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:
Next semester

(Recommended) Prerequisites:
Micro- and Macroeconomics

Content:
Many environmental issues, such as climate change, need to be considered globally. This course conveys concepts of optimal use of renewable and non-renewable resources in ex-ante viewing. In addition, the economics of water, energy markets, and natural resources such as fish and forest are deepened. Foundations of the New Institutional Economics illustrate the problem of the tragedy of common goods. Indicator systems such as Driver-Pressure-State-Impact-Response show the importance and complexity of environmental and sustainability measurement at national and international level.

Intended Learning Outcomes:
After attending the module, students will understand the role of renewable and non-renewable resources in the economy. Students can differentiate between the highest possible economic and sustainable return. They understand the functioning of energy and water markets. The students gain an understanding of the New Institutional Economy, especially land ownership and the sustainable use of public goods. In addition, students understand the measurement
of sustainability at the international and national level as well as the mathematical laws for the calculation of aggregated indices.

**Teaching and Learning Methods:**
The lecture and the seminar will be done by PowerPoint. In addition, articles from newspapers and journals are integrated into the lectures. In the seminar the students develop their own current case studies and discuss them from different perspectives based on the learned concepts and theories from the lecture. Classroom experiments are carried out for selected topics. Web lectures by internationally renowned experts and researchers will be integrated into the lecture.

**Media:**
Presentations, slide scripts, Articles, online lecture examples

**Reading List:**

**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](http://campus.tum.de) or [here](http://campus.tum.de).
Module Description

CS0098: Operations Research | Operations Research

Version of module description: Gültig ab winterterm 2020/21

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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:
Next 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 into the methods and approaches of Operations Research (OR). Operations Research deals with rational bases for decision making by seeking to understand and structure complex business situations and to use this understanding to predict system behavior and improve system performance.
Teaching and Learning Methods:
Lecture (theory), tutorials with group work and presentation

Media:
Seminaristic tuition using beamer, overhead projector, flipchart

Reading List:

Responsible for Module:
Alexander Hübner

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

CS0119: Behavioral Public Economics | Behavioral Public Economics

Version of module description: Gültig ab winterterm 2020/21

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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:
Next 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:**
Additional references of academic papers

**Responsible for Module:**
Sebastian Georg

**Courses (Type of course, Weekly hours per semester), Instructor:**
Behavioral Public Economics (Exercise) (Übung, 2 SWS)
Goerg S [L], Drobner C

Behavioral Public Economics (Lecture) (Vorlesung, 2 SWS)
Goerg S [L], Goerg S

For further information in this module, please click [campus.tum.de](http://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 2020/21

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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.

Alternative: For small groups (<15 students) parts of the exam can be held in case studies which have to be solved in a group. Thereby the students have to prove through the solution of an advanced problem that they are capable to apply methods and approaches of sustainability and life cycle assessment to emerging topics from the field. Weighting: 1:1.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
-

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 processes regarding 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:
• 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:**
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

CS0121: Sustainable Production | Sustainable Production [SP]

Version of module description: Gültig ab winterterm 2020/21

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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 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
- Individual 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:

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

Responsible for Module:
Magnus Fröhling
Courses (Type of course, Weekly hours per semester), Instructor:
Sustainable Production (Übung) (Übung, 2 SWS)
Fröhling M, Heinrich V

Sustainable Production (Vorlesung) (Vorlesung, 2 SWS)
Fröhling M [L], Fröhling M, Heinrich V
For further information in this module, please click campus.tum.de or here.
Electives | Major Schwerpunkt

Major Social Sciences | Major Social Sciences

Electives in (Bio-)Technology | Wahlmodule Bereich (Bio-)Technology

Module Description

CS0003: Production of Renewable Fuels | Production of Renewable Fuels

Version of module description: Gültig ab summerterm 2022

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<th>Module Level:</th>
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<td>English</td>
<td>one semester</td>
<td>winter semester</td>
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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 learning results are going to be proven in form of a written exam of 60 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:
Next 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 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:**
- George Olah et al.: Beyond Oil and Gas: The Methanol Economy, Wiley VCH (2006)

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

**Courses (Type of course, Weekly hours per semester), Instructor:**
Production of renewable fuels (Lecture, Garching) (Vorlesung, 2 SWS)
Burger J [L], Burger J

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

Production of renewable fuels (Tutorial, Straubing) (Übung, 2 SWS)
Burger J [L], Burger J, Rosen N

Production of renewable fuels (Tutorial, Garching) (Übung, 2 SWS)
Burger J [L], Burger J, Rosen N

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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<th>Module Level:</th>
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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:
Volker Sieber

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 summerterm 2022

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

Description of Examination Method:
To prove whether the students are able to understand and to describe possibilities and limitations of established industrial enzymatic processes and whether they are able to apply this knowledge 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). A bonus of 0.3 is credited on the grade of this written examination when during the module at least 65% of the exercises are marked with a positive result (yet, an increase of the grade from 4.3 to 4.0 is not possible). Thereby students shall be motivated to participate in the exercise which is very important for them.

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 resources 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:
Voker Sieber

Courses (Type of course, Weekly hours per semester), Instructor:
Enzymatic Biotransformations (Exercise) (Übung, 1 SWS)
Sieber V [L], Schmermund L

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 winterterm 2019/20

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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 machine learning 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:
Next semester

(Recommended) Prerequisites:
Basic Mathematical Skills, Basic Programming Skills

Content:
Technologies that generate analyses or predictions based on data can be found in almost all areas of our daily live (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, to predict 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 on various real-world problems.
The following contents will be treated exemplarily:
• Similarity and Distance Metrics
• Data Preprocessing and Visualization
• Classification
  o Nearest-Neighbor
  o Perceptron & Adaline
  o Logistic Regression
  o Decision Tree
o Support Vector Machines (SVM)
o Artificial Neuronal Networks
  • Model Selection and Hyperparameter Optimization
o Confusion Matrix and Evaluation Measures
o Cross-Validation
o Line Search
o Over- vs. Underfitting
  • Clustering
  o K-Means
o Hierarchical Clustering
  • Regression Models
o Linear Regression
o Support Vector Regression

**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.

**Teaching and Learning Methods:**
Lectures to provide the students with all necessary fundamentals of artificial intelligence, especially 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:**

**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

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

Version of module description: Gültig ab winterterm 2022/23

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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, a written examination takes place with a duration of 60 minutes. A bonus of 0.3 is credited on the grade of this written examination when during the module at least 65% of the exercise sheets are handed in and are marked with a positive result (an increase of the grade from 4.3 to 4.0 is not possible). Thereby students shall be motivated to participate in the tutorial which is very important for them.

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:**
Chemistry of Enzymes (Lecture) (Vorlesung, 1 SWS)
Sieber V [L], Al-Shameri A, Schermund L

Chemistry of Enzymes (Seminar) (Seminar, 1 SWS)
Sieber V [L], Al-Shameri A, Schermund L

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 2019/20

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<th>Module Level:</th>
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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:
Next 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 learn to implement custom Python scripts to analyse, visualise and interpret 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:**

**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

CS0086: Wood-based Resources | Wood-based Resources

Version of module description: Gültig ab winterterm 2021/22

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<th>Module Level:</th>
<th>Language:</th>
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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:
Next 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 and 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 so-called 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:**
Jörg van der Heide, 2011: Der Forstwirt. (The Forester) Publisher: Ulmer (Eugen); Auflage: 5th edition. (September 26, 2011)
Language: German
ISBN-10: 3800155702

**Responsible for Module:**
Prof. Cordt Zollfrank

**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

CS0092: Wind Power | Windkraft [Wind ]

Version of module description: Gültig ab summerterm 2022

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<th>Module Level:</th>
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Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
The basics of energy generation from wind are assessed in a written examination (60 minutes). The students prove that they have understood the technology of wind turbines and that they are able to carry out calculations on the design, energy yield and economic efficiency of wind turbines. They also show that they have understood the special problems in the project planning phase as well as during operation within the framework of legal requirements, the requirements for nature and species protection as well as the local acceptance of wind power use and ecology and acceptance and that they are able to evaluate plants and sites in this respect.

Repeat Examination:
Next semester

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

Content:
This module teaches in-depth knowledge about energy generation from wind power. The technology is described using the following points:
- Physical basics
- Designs and system components
- Planning, construction and operation
- Power output and energy supply

In addition to the technical characteristics of the plants, the module also focuses on their effects on the environment, legal framework conditions and economic
Intended Learning Outcomes:
Having attended the module, the students will be able to characterize and recognize different types of wind turbines and to understand them from a technical and energetic point of view. The students understand the processes involved in planning, erecting and operating wind turbines and are able to evaluate turbines from an economic and ecological point of view.

Teaching and Learning Methods:
The module consists of lecture and exercise. The contents of the lectures are primarily conveyed by the lecturers and through presentations. The students should get a well-founded insight into the topic. The exercises cover on the one hand technical calculations on wind turbines, on the other hand the different aspects of turbine project planning, in particular economic and ecological aspects, as well as acceptance by public. Among other things, plan and role plays in groups are planned to achieve this goal. Some of the exercises are to be prepared by the students themselves, others are to be carried out as face-to-face exercises. This should encourage students to work independently and to deal more intensively with the respective topics. Simulation and role-playing games help students to gain a deeper understanding of the opportunities and problems in the field of wind power technology.

Media:
PowerPoint, blackboard, publications

Reading List:

Responsible for Module:
Doris Schieder Doris.schieder@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Windkraft Vorlesung (Vorlesung, 1,5 SWS)
Schieder D [L], Schieder D, Widmann A

Windkraft Übung (Übung, 1 SWS)
Schieder D [L], Schieder D, Widmann A

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 winterterm 2020/21

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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 microbial biotechnological production processes, the students answer questions about production processes and fermentation strategies in a written exam (90 min, 50% weighting) and prove that they have understood the correlations of microbial metabolism. Allowed tools are calculators. The learning results in the field of plant biotechnology are going to be proved in form of a written exam (60 min., 50% weighting). In this written exam it will be evaluated to which extent the students are able to describe and assess the topics of the lecture correctly in appropriate scientific language. The seminar talk (20 Min., ungraded) will be evaluated to assess the ability of the students to correctly summarize the content of a complex scientific publication in the field of plant biotechnology and to comprehensively and convincingly present it to an audience.

Repeat Examination:
Next semester

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

Content:
Relevant topics and techniques of microbial biotechnology: - microbial metabolism (biosynthesis and degradation pathways) - industrial microbiology: production of alcohols, amino and organic acids, vitamins, antibiotics, enzymes, etc. - bioprocessing techniques - metabolic engineering strategies (e.g. optimization of precursor and cofactor availability) - quantitative biology. 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. Current topics will be discussed based on selected original publications. Some of the topics to be discussed: legal
framework, major application of current plant genetic engineering, the Arabidopsis model system, novel concepts for yield and quality improvement.

**Intended Learning Outcomes:**  
Upon successful completion of the module, students will be familiar with the principles and techniques of relevant 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 and to calculate mass balances. The students have acquired in-depth knowledge of relevant production processes for selected products of industrial biotechnology. 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. Seminar: recent publications will be selected and briefly discussed with the students, then presented by the students. The presentation will be discussed and evaluated.

**Media:**  
PowerPoint, whiteboard

**Reading List:**

**Responsible for Module:**  
Bastian Blombach bastian.blombach@tum.de

**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

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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 understand 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:
Broder Rühmann

Courses (Type of course, Weekly hours per semester), Instructor:
Einführung in die stoffliche Nutzung / Renewables Utilization (Exercise) (Übung, 2 SWS)
Rühmann B

Einführung in die stoffliche Nutzung / 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 winterterm 2021/22

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

Description of Examination Method:
Assessment takes an oral form (25 minutes). Students show the extent to which they have understood the taught definitions and terminology from the area of cooperative and non-cooperative games. 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. Students demonstrate their understanding of these solution concepts when answering comprehension questions concerning their properties and the advantages and disadcaantages of the different concepts.

Repeat Examination:
Next 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

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 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/or blackboard), tutorials with group work and exercise sheets

Reading List:

Responsible for Module:
Prof. Clemens Thielen

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

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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 be 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 research 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:
Cordt Zollfrank

Courses (Type of course, Weekly hours per semester), Instructor:
Biogenic Polymers (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Zollfrank C

Biogenic Polymers (Seminar) (Seminar, 1 SWS)
Zollfrank C [L], Zollfrank C

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


Version of module description: Gültig ab winterterm 2020/21

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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 acquired 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:
Next 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 exercise. Lectures include presentations whose content is deepened by solving exercise problems autonomously. In order to improve the learning outcome, participants work at homework exercise problems. These are discussed in the next lecture.

Media:
PP presentation, whiteboard, demonstration of programs

Reading List:

Responsible for Module:
Josef Kainz

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


Version of module description: Gültig ab summerterm 2022

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Description of Examination Method:
The module examination takes the form of a project work (report with a length of 15 pages and presentation of results with a length of 20 minutes). The final grade is calculated based on the individual grades from the presentation and report with a ratio of 1:1. The project work is used to check the extent to which the students can independently apply the aspects of energy-efficient buildings to one or more practical examples. A presentation shows whether the students can present their analyses of the energy efficiency of buildings in a comprehensible, precise and clear manner and at the same time can present themselves convincingly and professionally with rhetorical proficiency.

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 resource efficient building materials and construction. In addition, typical measures for the enhancement of energy efficiency in existing buildings will be presented and evaluated concerning their sustainability. The second part of the module is concerned with renewable 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 lectures and presentations. In addition, case studies and exercises will be discussed. Students should be encouraged to individual literature study and discussions on the theme.

Media:
PowerPoint, blackboard, videos

Reading List:

Responsible for Module:
Prof. Thomas Vienken thomas.vienken@hswt.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 2022

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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:
Basic knowledge in Machine Learning and Bioinformatics (e.g. Bioinformatics (WZ1631) and Artificial Intelligence for Biotechnology (CS0012))

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
- Genome-wide Association Studies
After these 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.

**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

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

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://www.example.com).
Module Description

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

Version of module description: Gültig ab summerterm 2022

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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:

Responsible for Module:
Matthias Gaderer gaderer@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Energy and Economics (Exercise) (Übung, 1 SWS)
Gaderer M [L], Naumann G, Schropp E

Energy and Economics (Lecture) (Vorlesung, 3 SWS)
Gaderer M [L], Naumann G, Schropp E

For further information in this module, please click campus.tum.de or here.
Electives in Social Sciences, Sustainability, and Technology | Wahlmodule Bereich Social Sciences, Sustainability, and Technology

Module Description

WZ1136: Business Analysis and Management | Unternehmensanalyse und -management

Version of module description: Gültig ab winterterm 2015/16

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Description of Examination Method:
One part of the assessment takes the form of a written examination (60 minutes) with students reflecting the theoretical basics of business analysis. In addition, students are expected to develop a business plan during the course of the semester. The compulsory presentation (30 minutes) contributes to the assessment and will examine the students' ability to put their knowledge of business management into practice. Written examination and oral presentation of the business plan weigh at a ratio of 1 to 3, respectively, according to the teaching hours per week.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
none

Content:
The lecture is subdivided into two parts:
1. Lectures: business plan in the field of renewable resources

This course involves creating a mock business plan to set up a company. To that end, students work in small groups to develop a business plan which will be presented to the class. The business plan must contain:
- Executive summary
- Business model and concept
- Management team
- Target market, market and competition
- Marketing and sales
- Business system and organization
- Road map for goals
- Opportunities and risks
- Financial planning and financing

2. Lectures: business analysis
Business analysis of selected business areas related to renewable resources (e.g. biogas station with CHP; effects of changed framework conditions), work on case examples

**Intended Learning Outcomes:**
After their participation, students are aware of basic requirements to set up a company. Lectures are designed to enhance business thinking. In addition, students can understand relationships in the areas of production technology and business administration relevant to companies in the field of renewable resources.

**Teaching and Learning Methods:**
Lecture (talks given by teaching staff)
Seminar (students independently study a special topic, with subsequent presentation and final report on it)

**Media:**
Presentation, excursion

**Reading List:**
Fueglistaller, Urs; Müller, Christoph A.; Volery, Thierry: *Entrepreneurship, 2., überarb. u. erw. Aufl.*, Gabler Wiesbaden, 2008.

**Responsible for Module:**
Hubert Röder (hubert.roeder@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**
Businessplan NAWARO (Übung) (Übung, 1 SWS)
Röder H [L], Röder H

Businessplan NAWARO (Vorlesung) (Vorlesung, 2 SWS)
Röder H [L], Röder H

Unternehmensanalyse und -management (Vorlesung, 1 SWS)
Röder H (L), Röder H
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

<table>
<thead>
<tr>
<th>Module Level: Bachelor/Master</th>
<th>Language: English</th>
<th>Duration: one semester</th>
<th>Frequency: summer semester</th>
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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:
Overcoming Obstacles - the Bumpy Road toward Carbon Neutrality (Ringvorlesung Umwelt) - Garching (Vorlesung mit integrierten Übungen, 1,5 SWS)
Fahmy M, Kopp-Gebauer B, Recknagel F, Slanitz A, Zimmermann P
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

<table>
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<tr>
<th>Module Level: Bachelor/Master</th>
<th>Language: English</th>
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<th>Frequency: winter/summer semester</th>
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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 für 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:**
Overcoming Obstacles - the Bumpy Road toward Carbon Neutrality (Ringvorlesung Umwelt) - Garching (Vorlesung mit integrierten Übungen, 1,5 SWS)
Fahmy M, Kopp-Gebauer B, Recknagel F, Slanitz A, Zimmermann P
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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<tr>
<th>Module Level:</th>
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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:
Volker Sieber

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 summerterm 2022

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

Description of Examination Method:
To prove whether the students are able to understand and to describe possibilities and limitations of established industrial enzymatic processes and whether they are able to apply this knowledge 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). A bonus of 0.3 is credited on the grade of this written examination when during the module at least 65% of the exercises are marked with a positive result (yet, an increase of the grade from 4.3 to 4.0 is not possible). Thereby students shall be motivated to participate in the exercise which is very important for them.

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 resources 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:
Voker Sieber

Courses (Type of course, Weekly hours per semester), Instructor:
Enzymatic Biotransformations (Exercise) (Übung, 1 SWS)
Sieber V [L], Schmermund L

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 winterterm 2019/20

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<th>Module Level:</th>
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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 machine learning 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:
Next semester

(Recommended) Prerequisites:
Basic Mathematical Skills, Basic Programming Skills

Content:
Technologies that generate analyses or predictions based on data can be found in almost all areas of our daily live (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 to predict 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 on various real-world problems.
The following contents will be treated exemplarily:
• Similarity and Distance Metrics
• Data Preprocessing and Visualization
• Classification
 o Nearest-Neighbor
 o Perceptron & Adaline
 o Logistic Regression
 o Decision Tree
o Support Vector Machines (SVM)
o Artificial Neuronal Networks
• Model Selection and Hyperparameter Optimization
o Confusion Matrix and Evaluation Measures
o Cross-Validation
o Line Search
o Over- vs. Underfitting
• Clustering
o K-Means
o Hierarchical Clustering
• Regression Models
o Linear Regression
o Support Vector Regression

**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.

**Teaching and Learning Methods:**
Lectures to provide the students with all necessary fundamentals of artificial intelligence, especially 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:**

**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

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

Version of module description: Gültig ab winterterm 2022/23

<table>
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<th>Language: English</th>
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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, a written examination takes place with a duration of 60 minutes. A bonus of 0,3 is credited on the grade of this written examination when during the module at least 65% of the exercise sheets are handed in and are marked with a positive result (an increase of the grade from 4,3 to 4,0 is not possible). Thereby students shall be motivated to participate in the tutorial which is very important for them.

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:**
Chemistry of Enzymes (Lecture) (Vorlesung, 1 SWS)
Sieber V [L], Al-Shameri A, Schmermund L

Chemistry of Enzymes (Seminar) (Seminar, 1 SWS)
Sieber V [L], Al-Shameri A, Schmermund L

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or here.
Module Description

CS0026: Advanced Concepts of Bioinformatics | Advanced Concepts of Bioinformatics

Version of module description: Gültig ab winterterm 2019/20

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<tbody>
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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:
Next 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 learn to implement custom Python scripts to analyse, visualise and interpret 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:**

**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](http://campus.tum.de) or [here](http://here).
Module Description

CS0086: Wood-based Resources | Wood-based Resources

Version of module description: Gültig ab winterterm 2021/22

Module Level:
Bachelor

Language:
German/English

Duration:
one semester

Frequency:
winter semester

<table>
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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:
Next 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 and 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 so-called 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:**
Jörg van der Heide, 2011: Der Forstwirt. (The Forester) Publisher: Ulmer (Eugen); Auflage: 5th edition. (September 26, 2011)
Language: German
ISBN-10: 3800155702

**Responsible for Module:**
Prof. Cordt Zollfrank

**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 winterterm 2020/21

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<td>120</td>
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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 microbial biotechnological production processes, the students answer questions about production processes and fermentation strategies in a written exam (90 min, 50% weighting) and prove that they have understood the correlations of microbial metabolism. Allowed tools are calculators. The learning results in the field of plant biotechnology are going to be proved in form of a written exam (60 min., 50% weighting). In this written exam it will be evaluated to which extent the students are able to describe and assess the topics of the lecture correctly in appropriate scientific language. The seminar talk (20 Min., ungraded) will be evaluated to assess the ability of the students to correctly summarize the content of a complex scientific publication in the field of plant biotechnology and to comprehensively and convincingly present it to an audience.

Repeat Examination:
Next semester

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

Content:
Relevant topics and techniques of microbial biotechnology: - microbial metabolism (biosynthesis and degradation pathways) - industrial microbiology: production of alcohols, amino and organic acids, vitamins, antibiotics, enzymes, etc. - bioprocessing techniques - metabolic engineering strategies (e.g. optimization of precursor and cofactor availability) - quantitative biology. 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. Current topics will be discussed based on selected original publications. Some of the topics to be discussed: legal
framework, major application of current plant genetic engineering, the Arabidopsis model system, novel concepts for yield and quality improvement.

**Intended Learning Outcomes:**
Upon successful completion of the module, students will be familiar with the principles and techniques of relevant 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 and to calculate mass balances. The students have acquired in-depth knowledge of relevant production processes for selected products of industrial biotechnology. 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. Seminar: recent publications will be selected and briefly discussed with the students, then presented by the students. The presentation will be discussed and evaluated.

**Media:**
PowerPoint, whiteboard

**Reading List:**

**Responsible for Module:**
Bastian Blombach bastian.blombach@tum.de

**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](http://campus.tum.de) or [here](http://campus.tum.de).
Module Description

CS0101: Renewables Utilization | Renewables Utilization

Version of module description: Gültig ab winterterm 2020/21

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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 understand 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:
Broder Rühmann

Courses (Type of course, Weekly hours per semester), Instructor:
Einführung in die stoffliche Nutzung / Renewables Utilization (Exercise) (Übung, 2 SWS)
Rühmann B

Einführung in die stoffliche Nutzung / 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

CS0104: Biogenic Polymers | Biogenic Polymers [Bioplar]

Version of module description: Gültig ab winterterm 2020/21

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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 be 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 research 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:**
Cordt Zollfrank

**Courses (Type of course, Weekly hours per semester), Instructor:**
Biogenic Polymers (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Zollfrank C

Biogenic Polymers (Seminar) (Seminar, 1 SWS)
Zollfrank C [L], Zollfrank C

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


Version of module description: Gültig ab winterterm 2020/21

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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 acquired 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:
Next 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:

Responsible for Module:
Josef Kainz

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

CS0111: Advanced Development Economics | Advanced Development Economics

Version of module description: Gültig ab winterterm 2020/21

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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:
Next 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. private 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 seminar will be done by PowerPoint. In addition, current examples from newspapers and journals will be integrated into the lectures. In the seminar, 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:**

**Responsible for Module:**
Anja Faße

**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

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 2020/21

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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:
Next 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, which forms the basis of the students' seminar papers. After the introductory session, students will work out the topic on their own, by using their abilities 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], Riesenegger L, Tuma N, Wink K, Yang X
For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http:// somewhere).
Module Description

CS0113: Innovation in Bioeconomy | Innovation in Bioeconomy

Version of module description: Gültig ab winterterm 2020/21

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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 with a focus on bioeconomic questions and concepts. Building on a core understanding of the principles of innovation management, students will answer questions about the more recent innovation concepts that are driven by digitalization and have the ability to explain the adapted strategies and options for firms. They will also be able to assess the relevance of digital technologies and the different options to design digital business models in the context of bioeconomic questions.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Entrepreneurship, Introduction to Innovation Management

Content:
The module introduces students into advanced principles of innovation management from a digital and sustainable perspective. Students will be equipped with basic knowledge on:
- content and relevance of digital technologies
- role of ecosystems, platforms and networks
- design of business models to implement sustainable innovation
- advanced methods to generate and implement innovation
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 organising innovation in the context of digitalization by including broader economic, environmental and societal effects
- derive recommendations about the design and practices of innovation managements and how to implement sustainable innovation
- identify and evaluate digital 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:**

**Responsible for Module:**
Claudia Doblinger

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

Innovation in Bioeconomy (Lecture) (Vorlesung, 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 2020/21

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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:
Next 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:

Responsible for Module:
Prof. Dr. Anja Faße

Courses (Type of course, Weekly hours per semester), Instructor:
International Trade (Seminar) (Seminar, 2 SWS)
Faße A [L], Faße A

International Trade (Lecture) (Vorlesung, 2 SWS)
Faße A [L], Faße A (Hering A)

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

CS0116: Markets for Energy and Biobased Products | Markets for Energy and Biobased Products

Version of module description: Gültig ab winterterm 2020/21

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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 oral examination as well as students' presentation. The students should be able to evaluate and use the taught methods of market analysis. In addition, questions related to the market development and important influencing factors on markets of energy and biobased products are discussed in the oral examination. No additional tools are allowed during oral examination. Duration of oral examination: 20 minutes. The proportion of the oral examination is 70% of the total grade.
The students' presentation 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 this presentation. Duration of presentation: 30 minutes. The proportion of the presentation is 30% of the total grade.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Micro-economics

Content:
The content of the module comprises of theory and tools for analysing markets. This knowledge will be used to analyse the development, situation and important determinants of market development in selected energy markets and markets for biogenic products. Thereby the different markets will be regarded from raw material production over the entire value chain to the (private) consumers. In the energy field, markets for fossile raw materials (e.g. crude oil, natural gas, coal) will be considered as well as markets for regenerative energy production (e.g. wind, hydro, solar energy, use of biomass) for heating, mobility and power. In addition, selected markets for material
use of biogenic resources will be covered (like e.g. bulk chemicals, biogenic insulation materials, biogenic polymers, WPC, bioplastics, biocosmetics, detergents and cleaning material, biobased consumer products). Besides, the students will use the taught methods and tools in a students' project in which actual questions related to the market situation and development in selected markets will be analysed.

**Intended Learning Outcomes:**
After attending the module, students will be able to analyse the developments of markets as well as to select and use the adequate methods in a targeted way. Students are familiar with the relevance, size, development and important influencing factors on the energy markets as well as markets for material use of biogenic resources. They are able to independently analyse these markets, to interpret important determinants of market development, and to assess the use of fossil and regenerative energies as well as the use of biomass for material applications in a macroeconomic and societal context thus developing strategies for future use.

**Teaching and Learning Methods:**
The lecture will be done using Powerpoint with specifically worked out presentation scripts. In addition, published studies and statistical data related to the development and situation on the targeted markets will be integrated into the lectures. In the students' project, students use the taught market analysis methods and tools as well as their factual knowledge to analyse actual questions and developments on selected markets. They will present and discuss their approach and solutions with their colleagues and the lecturers.

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

**Reading List:**

**Responsible for Module:**
Prof. Klaus Menrad

**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 winterterm 2020/21

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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 oral examination as well as students' presentation. The students should be able to evaluate and use the methods of consumer and market research that were thaugt in the module. No additional tools are allowed during oral examination. Duration of oral examination: 20 minutes. The proportion of the oral examination is 50% of the total grade. The students' presentation 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 lecturer. Powerpoint and presentation equipment are allowed for this presentation. Duration of presentation: 30 minutes. The proportion of the presentation is 50% of the total grade.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
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 interpret 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 R or SPSS for quantitative statistical 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 colleagues and lecturers.

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

**Reading List:**

**Responsible for Module:**
Klaus Menrad

**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 2020/21

<table>
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<th>Module Level: Master</th>
<th>Language: English</th>
<th>Duration: one semester</th>
<th>Frequency: winter semester</th>
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<tr>
<td>Credits:* 6</td>
<td>Total Hours: 180</td>
<td>Self-study Hours: 120</td>
<td>Contact Hours: 60</td>
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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:
Next 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:

Responsible for Module:
Anja Faße

Courses (Type of course, Weekly hours per semester), Instructor:
Environmental Accounting in Economics and Sustainability Sciences (Exercise) (Vorlesung mit integrierten Übungen, 2 SWS)
Faße A [L], Faße A, Voss R

Environmental Accounting in Economics and Sustainability Sciences (Lecture) (Vorlesung, 2 SWS)
Faße A [L], Faße A, Voss R

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 winterterm 2020/21

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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

Repeat Examination:
Next 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:**
Sebastian Georg

**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 summerterm 2022

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<th>Module Level:</th>
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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

Repeat Examination:
Next 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:**

**Responsible for Module:**
Prof. Sebastian Georg

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

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](#).
Module Description

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

Version of module description: Gültig ab winterterm 2020/21

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<th>Module Level: Master</th>
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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 abilities 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
- Individual assignments and presentation
The teaching and learning methods are combined 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:
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](http://campus.tum.de) or [here](http://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 summerterm 2021

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

**Description of Examination Method:**

"Term paper and presentation: 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. In the 30 minute final presentation they have to to show that they are able to summarize their findings in a scientific presentation, discuss and defend them (20' for presentation, 10' for discussion).

Weighting: Term paper 2, Presentation 1"

**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 preceding semester.

**Intended Learning Outcomes:**

The seminar aims at enabling students for scientific work. After passing the module the students 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-depth 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 scientific paper, Cambridge University 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:
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

CS0128: Corporate Sustainability Management | Corporate Sustainability Management

Version of module description: Gültig ab winterterm 2020/21

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<th>Module Level:</th>
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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 60 minute written final exam and a 20 minute oral presentation. The students calculate key performance indicators for sustainable management and illustrate decision-making procedures and alternatives based on case studies. They show that they are able to outline and explain business processes of sustainable management. They demonstrate that they are able to answer questions on sustainable management in their own words. The oral presentation shall be assessed according to content and rhetoric aspects. 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:
-

Content:
The module of sustainable management includes a detailed discussion about the term of sustainability (four-pillar model) and its historical development. Basic premises for sustainable management or sustainable development shall be derived from it and discussed in the social, political, economical and business context. National, European and international strategies for sustainable economics shall be introduced (e.g. Bioeconomy, Circular Economy, Green Economy, Agenda 21). Furthermore current measuring concepts and key performance indicators for sustainability (e.g. resource productivity, life cycle costing) shall be treated and applied to exemplary products and value chains and discussed in the framework of “corporate social responsibility reporting”. 
Intended Learning Outcomes:
After having participated in the module the students are able to understand sustainability concepts and to compare sustainability-oriented corporate images as a supplement to value added oriented corporate images. They are able to perform sustainability assessments based on current measuring concepts and key performance indicators. They are able to represent products and services within the scope of sustainable forms of economy.

Teaching and Learning Methods:
The module consists of a lecture and an exercise. During the lectures the contents are delivered by presentations and discussions. The lectures are used to convey the theoretical 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. Students deepen their understanding through working in small student groups as well as solving exercises on their own.

Media:
Presentations, slide scripts

Reading List:

Responsible for Module:
Hubert Röder

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

Version of module description: Gültig ab winterterm 2021/22

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<th>Module Level:</th>
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<td>Master</td>
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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:
Next 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 tuition using beamer, overhead projector, flipchart

Reading List:
Cachon/Terwiesch (2012): Matching Supply with Demand

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

CS0170: Advanced Modelling and Optimization

Version of module description: Gültig ab winterterm 2021/22

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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, applying 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:

(Recommended) Prerequisites:
Operations Research (CS0098)
Content:
This course is about modeling, solving and analyzing planning and decision problems using mathematical 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 opportunites to implement problems 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:
Popp, Andreas: Modellierung und Optimierung mit OPL. epubli, 2015

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 summerterm 2022

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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 taught 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:
Next 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 taught 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:**
Prof. Klaus Menrad

**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

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<td>120</td>
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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:
• 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], Wink K, Winkler T
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 2021/22

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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:
Next 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:

Responsible for Module:
Alexander Hübner

Courses (Type of course, Weekly hours per semester), Instructor:
Discrete Event Simulation (Lecture) (Vorlesung, 2 SWS)
Hübner A [L], Schäfer F
Discrete Event Simulation (Exercise) (Übung, 2 SWS)
Hübner A [L], 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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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,
CS0226: Corporate Strategy | Corporate Strategy

• 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

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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:
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 spreadsheets 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:

**Responsible for Module:**
Magnus Fröhling
Courses (Type of course, Weekly hours per semester), Instructor:
LCA Case Studies (Seminar, 3 SWS)
Fröhling M [L], Fröhling M, Lohmeyer R
For further information in this module, please click campus.tum.de or here.
Module Description

CS0228: Technology and Management of Renewable Energies in Africa and the EU | Technology and Management of Renewable Energies in Africa and the EU [REAE]

Version of module description: Gültig ab summerterm 2021

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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 (30 minutes) and a short report of the students' project work. 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 Africa or in the EU. 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 country context. The presentation will be passed over to the lecturers as well as the short report and will be included in the grading.

Repeat Examination:
Next 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

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 in the EU and in Africa (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 in the EU and in Africa. Thereby 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 a country of the EU or in Africa into account when analysing and elaborating solutions for the question on-hand. They are able to apply their knowledge to create an oral presentation. 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 (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:
Prof. Dr. Klaus Menrad

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

Version of module description: Gültig ab winterterm 2021/22

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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:
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:

(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 policies. 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:**
Bibliography of scientific publications

**Responsible for Module:**
Andreas Pondorfer

**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

CS0244: Inventory and Transportation Management | Inventory and Transportation Management

Version of module description: Gültig ab winterterm 2021/22

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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:
Next 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:
Günther, H.O., Tempelmeier, H. (2020), Supply Chain Analytics

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

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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:**
- Alberto Bisin and Giovanni Federico (2021), The Handbook of Historical Economics, Academic Press
- Bibliography of scientific publications

**Responsible for Module:**
Andreas Pondorfer (andreas.pondorfer@tum.de)

**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](http://campus.tum.de) or [here](http://campus.tum.de).
**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 winterterm 2022/23

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<th>Module Level:</th>
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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’ presentation.

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: 45 minutes. The proportion of the written examination is 50% of the total grade.

The students' presentation 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 this presentation. Duration of presentation: 20 minutes. The proportion of the presentation is 50% of the total grade.

**Repeat Examination:**

**(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. Sawtooth).

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:
- Sawtooth manuels

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)
Decker T [L], Decker T, Pondorfer A
For further information in this module, please click campus.tum.de or here.
Module Description

CS0277: Sustainability and Risk Management

Version of module description: Gültig ab winterterm 2022/23

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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:

(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:**
• Shin, Hyun Song (2019) Risk and Liquidity, Claredon Lectures in Finance
• Selected publications from Basel Committee on Banking Supervision, ESAs, EPCC, WMO.
• 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

**Responsible for Module:**
Viktoriia Shkola (viktoriia.shkola@tum.de)

**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 winterterm 2022/23

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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
- Circularity Gap Report Global (2022); https://www.circularity-gap.world/2022
- Lewrick, Michael: Design Thinking for Business Growth: How to Design and Scale Business Models and Business Ecosystems (2022), Wiley
- 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.unpd.org/sustainable-development-goals?
  utm_source=EN&utm_medium=GSR&utm_content=US_UNDP_PaidSearch_Brand_English&utm_campaign=CGlVhuJ3Ch3pVQtFEAAYAyAAEGlnGvD_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
  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], Fröhling M

Case study driven seminar on Sustainability and Innovation Management in an Industrial Context
(Seminar, 2 SWS)
Fröhling M [L], Fröhling M

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

Build innovative products of your ideas in 10 days!
Version of module description: Gültig ab summerterm 2021

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<td>Master</td>
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Credits:* 6
Total Hours: 180
Self-study Hours: 60
Contact Hours: 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:

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 the successful participation in the module, the students are able to:
- examine the relevance of a problem and develop a solution collaboratively in an interdisciplinary team.
- to discover the innovation potentials of new products / ideas, to evaluate the novelty and social relevance.
- To convert one’s own ideas into a Minimum Viable Product and thus use potentials for one’s own business start-up.
- To know methods of product development (from thinking to doing), to apply them independently and to evaluate the results (prototyping, design thinking, lean startup, agile, systems engineering).
- to reproduce the principles of user-centred design, to apply them independently and to evaluate them.
- Understand the context of use and analyse customer needs (where do I serve a need and what technology/method do I use).
- To quickly develop important hypotheses involving relevant stakeholders (customer, user, ...) through proper Planning with "purposeful prototyping".
- Change perspectives across disciplines and apply project management in interdisciplinary teamwork.
- To work independently, to make and justify decisions and to learn from one's own mistakes.
- To possibly 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:**


Kelly, Tom (2016): The Art of Innovation

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

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


Ries, Eric (2011): The Lean Startup

Savoia, Antonio (2019): The right It


**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], Martins Pacheco N, Tong Y, Reif M, Bandle M, Baur C, Thies A, Hohnbaum K, Schmid F, Büchner B

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://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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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 reexamine 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, participants 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):


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

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Seminar Economics & Policy: Decisions under Uncertainty from Description and from Experience (Seminar, 4 SWS)
Kopsacheilis O
For further information in this module, please click campus.tum.de or here.
Major Bio-Technology | Major Bio-Technology

Electives in (Bio-)Technology | Wahlmodule Bereich (Bio-)Technology

Module Description

CS0003: Production of Renewable Fuels | Production of Renewable Fuels

Version of module description: Gültig ab summerterm 2022

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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 60 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:
Next 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 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:**
- George Olah et al.: Beyond Oil and Gas: The Methanol Economy, Wiley VCH (2006)

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

**Courses (Type of course, Weekly hours per semester), Instructor:**
Production of renewable fuels (Lecture, Garching) (Vorlesung, 2 SWS)  
Burger J [L], Burger J

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

Production of renewable fuels (Tutorial, Garching) (Übung, 2 SWS)  
Burger J [L], Burger J, Rosen N

Production of renewable fuels (Tutorial, Straubing) (Übung, 2 SWS)  
Burger J [L], Burger J, Rosen N

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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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:
Volker Sieber

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 summerterm 2022

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

Description of Examination Method:
To prove whether the students are able to understand and to describe possibilities and limitations of established industrial enzymatic processes and whether they are able to apply this knowledge 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). A bonus of 0,3 is credited on the grade of this written examination when during the module at least 65% of the exercises are marked with a positive result (yet,an increase of the grade from 4,3 to 4,0 is not possible). Thereby students shall be motivated to participate in the exercise which is very important for them.

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:
Voker Sieber

Courses (Type of course, Weekly hours per semester), Instructor:
Enzymatic Biotransformations (Exercise) (Übung, 1 SWS)
Sieber V [L], Schmermund L

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 winterterm 2019/20

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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 machine learning 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:
Next semester

(Recommended) Prerequisites:
Basic Mathematical Skills, Basic Programming Skills

Content:
Technologies that generate analyses or predictions based on data can be found in almost all areas of our daily live (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, to predict 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 on various real-world problems.
The following contents will be treated exemplarily:
• Similarity and Distance Metrics
• Data Preprocessing and Visualization
• Classification
  o Nearest-Neighbor
  o Perceptron & Adaline
  o Logistic Regression
  o Decision Tree
o Support Vector Machines (SVM)
  o Artificial Neuronal Networks
    • Model Selection and Hyperparameter Optimization
  o Confusion Matrix and Evaluation Measures
  o Cross-Validation
  o Line Search
  o Over- vs. Underfitting
    • Clustering
    o K-Means
  o Hierarchical Clustering
    • Regression Models
  o Linear Regression
  o Support Vector Regression

**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.

**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:**

**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

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

Version of module description: Gültig ab winterterm 2022/23

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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, a written examination takes place with a duration of 60 minutes. A bonus of 0,3 is credited on the grade of this written examination when during the module at least 65% of the exercise sheets are handed in and are marked with a positive result (an increase of the grade from 4,3 to 4,0 is not possible). Thereby students shall be motivated to participate in the tutorial which is very important for them.

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:**
Chemistry of Enzymes (Lecture) (Vorlesung, 1 SWS)
Sieber V [L], Al-Shameri A, Schmermund L

Chemistry of Enzymes (Seminar) (Seminar, 1 SWS)
Sieber V [L], Al-Shameri A, Schmermund L

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or here.
Module Description

CS0026: Advanced Concepts of Bioinformatics

Version of module description: Gültig ab winterterm 2019/20

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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:
Next 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 learn to implement custom Python scripts to analyse, visualise and interpret 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:**

**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

CS0086: Wood-based Resources | Wood-based Resources

Version of module description: Gültig ab winterterm 2021/22

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<th>Module Level:</th>
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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:
Next 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 and 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 so-called 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:**
Jörg van der Heide, 2011: Der Forstwirt. (The Forester) Publisher: Ulmer (Eugen); Auflage: 5th edition. (September 26, 2011)
Language: German
ISBN-10: 3800155702

**Responsible for Module:**
Prof. Cordt Zollfrank

**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](http://campus.tum.de) or here.
Module Description

CS0092: Wind Power | Windkraft [Wind ]

Version of module description: Gültig ab sommerterm 2022

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

Description of Examination Method:
The basics of energy generation from wind are assessed in a written examination (60 minutes). The students prove that they have understood the technology of wind turbines and that they are able to carry out calculations on the design, energy yield and economic efficiency of wind turbines. They also show that they have understood the special problems in the project planning phase as well as during operation within the framework of legal requirements, the requirements for nature and species protection as well as the local acceptance of wind power use and ecology and acceptance and that they are able to evaluate plants and sites in this respect.

Repeat Examination:
Next semester

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

Content:
This module teaches in-depth knowledge about energy generation from wind power. The technology is described using the following points:
- Physical basics
- Designs and system components
- Planning, construction and operation
- Power output and energy supply
In addition to the technical characteristics of the plants, the module also focuses on their effects on the environment, legal framework conditions and economic
Intended Learning Outcomes:
Having attended the module, the students will be able to characterize and recognize different types of wind turbines and to understand them from a technical and energetic point of view. The students understand the processes involved in planning, erecting and operating wind turbines and are able to evaluate turbines from an economic and ecological point of view.

Teaching and Learning Methods:
The module consists of lecture and exercise. The contents of the lectures are primarily conveyed by the lecturers and through presentations. The students should get a well-founded insight into the topic. The exercises cover on the one hand technical calculations on wind turbines, on the other hand the different aspects of turbine project planning, in particular economic and ecological aspects, as well as acceptance by public. Among other things, plan and role plays in groups are planned to acheive this goal. Some of the exercises are to be prepared by the students themselves, others are to be carried out as face-to-face exercises. This should encourage students to work independently and to deal more intensively with the respective topics. Simulation and role-playing games help students to gain a deeper understanding of the opportunities and problems in the field of wind power technology.

Media:
PowerPoint, blackboard, publications

Reading List:

Responsible for Module:
Doris Schieder Doris.schieder@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:
Windkraft Vorlesung (Vorlesung, 1,5 SWS)
Schieder D [L], Schieder D, Widmann A

Windkraft Übung (Übung, 1 SWS)
Schieder D [L], Schieder D, Widmann A
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 winterterm 2020/21

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<th>Module Level:</th>
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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 microbial biotechnological production processes, the students answer questions about production processes and fermentation strategies in a written exam (90 min, 50% weighting) and prove that they have understood the correlations of microbial metabolism. Allowed tools are calculators. The learning results in the field of plant biotechnology are going to be proved in form of a written exam (60 min., 50% weighting). In this written exam it will be evaluated to which extent the students are able to describe and assess the topics of the lecture correctly in appropriate scientific language. The seminar talk (20 Min., ungraded) will be evaluated to assess the ability of the students to correctly summarize the content of a complex scientific publication in the field of plant biotechnology and to comprehensively and convincingly present it to an audience.

Repeat Examination:

Next semester

(Recommended) Prerequisites:

Fundamentals of Biology or of cell and microbiology from the Bachelor's courses

Content:

Relevant topics and techniques of microbial biotechnology: - microbial metabolism (biosynthesis and degradation pathways) - industrial microbiology: production of alcohols, amino and organic acids, vitamins, antibiotics, enzymes, etc. - bioprocessing techniques - metabolic engineering strategies (e.g. optimization of precursor and cofactor availability) - quantitative biology. 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 their pros and cons. Current topics will be discussed based on selected original publications. Some of the topics to be discussed: legal
framework, major application of current plant genetic engineering, the Arabidopsis model system, novel concepts for yield and quality improvement.

**Intended Learning Outcomes:**
Upon successful completion of the module, students will be familiar with the principles and techniques of relevant 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 and to calculate mass balances. The students have acquired in-depth knowledge of relevant production processes for selected products of industrial biotechnology. 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. Seminar: recent publications will be selected and briefly discussed with the students, then presented by the students. The presentation will be discussed and evaluated.

**Media:**
PowerPoint, whiteboard

**Reading List:**

**Responsible for Module:**
Bastian Blombach bastian.blombach@tum.de

**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

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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 understand 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:
Broder Rühmann

Courses (Type of course, Weekly hours per semester), Instructor:
Einführung in die stoffliche Nutzung / Renewables Utilization (Exercise) (Übung, 2 SWS)
Rühmann B

Einführung in die stoffliche Nutzung / 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 winterterm 2021/22

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

Description of Examination Method:
Assessment takes an oral form (25 minutes). Students show the extent to which they have understood the taught definitions and terminology from the area of cooperative and non-cooperative games. 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. Students demonstrate their understanding of these solution concepts when answering comprehension questions concerning their properties and the advantages and disadcentages of the different concepts.

Repeat Examination:
Next 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

Intended Learning Outcomes:
Students have acquired basic theoretical and practical knowledge on cooperative and non-cooperative games. They know the basic definitions and terminology and are able to model 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/or blackboard), tutorials with group work and exercise sheets

Reading List:

Responsible for Module:
Prof. Clemens Thielen

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

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<th>Module Level:</th>
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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 be 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 research 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:
Cordt Zollfrank

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

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**


Version of module description: Gültig ab winterterm 2020/21

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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 acquired 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:**
Next 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 exercise. Lectures include presentations whose content is deepened by solving exercise problems autonomously. In order to improve the learning outcome, participants work at homework exercise problems. These are discussed in the next lecture.

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

**Reading List:**

**Responsible for Module:**
Josef Kainz

**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](http://campus.tum.de) or [here](http://here).
Module Description


Version of module description: Gültig ab summerterm 2022

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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 project work (report with a length of 15 pages and presentation of results with a length of 20 minutes). The final grade is calculated based on the individual grades from the presentation and report with a ratio of 1:1. The project work is used to check the extent to which the students can independently apply the aspects of energy-efficient buildings to one or more practical examples. A presentation shows whether the students can present their analyses of the energy efficiency of buildings in a comprehensible, precise and clear manner and at the same time can present themselves convincingly and professionally with rhetorical proficiency.

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 resource efficient building materials and construction. In addition, typical measures for the enhancement of energy efficiency in existing buildings will be presented and evaluated concerning their sustainability. The second part of the module is concerned with renewable 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 lectures and presentations. In addition, case studies and exercises will be discussed. Students should be encouraged to individual literature study and discussions on the theme.

**Media:**
PowerPoint, blackboard, videos

**Reading List:**

**Responsible for Module:**
Prof. Thomas Vienken thomas.vienken@hswt.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

Version of module description: Gültig ab summerterm 2022

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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:
Basic knowledge in Machine Learning and Bioinformatics (e.g. Bioinformatics (WZ1631) and Artificial Intelligence for Biotechnology (CS0012))

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
- Genome-wide Association Studies
CS0255: Current Topics in Machine Learning and Bioinformatics | Current Topics in Machine Learning and Bioinformatics

[CTMLBI]

- Phenotype Prediction
- Protein-Protein Interaction Network Analysis
- Protein Prediction
- Data Driven Biotechnology

After these 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.

**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

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

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://here).
Module Description

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

Version of module description: Gültig ab summerterm 2022

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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:  

Responsible for Module:  
Matthias Gaderer gaderer@tum.de

Courses (Type of course, Weekly hours per semester), Instructor:  
Energy and Economics (Exercise) (Übung, 1 SWS)  
Gaderer M [L], Naumann G, Schropp E

Energy and Economics (Lecture) (Vorlesung, 3 SWS)  
Gaderer M [L], Naumann G, Schropp E

For further information in this module, please click campus.tum.de or here.
Electives in Social Sciences, Sustainability, and Technology | Wahlmodule Bereich Social Sciences, Sustainability, and Technology

Module Description

WZ1136: Business Analysis and Management | Unternehmensanalyse und -management

Version of module description: Gültig ab winterterm 2015/16

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

Description of Examination Method:
One part of the assessment takes the form of a written examination (60 minutes) with students reflecting the theoretical basics of business analysis. In addition, students are expected to develop a business plan during the course of the semester. The compulsory presentation (30 minutes) contributes to the assessment and will examine the students' ability to put their knowledge of business management into practice. Written examination and oral presentation of the business plan weigh at a ration of 1 to 3, respectively, according to the teaching hours per week.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
none

Content:
The lecture is subdivided into two parts:
1. Lectures: business plan in the field of renewable resources
This course involves creating a mock business plan to set up a company. To that end, students work in small groups to develop a business plan which will be presented to the class. The business plan must contain:
- Executive summary
- Business model and concept
- Management team
- Target market, market and competition

Module Catalog of the study program M.Sc. Bioeconomy
Generated on 31.10.2022
- Marketing and sales
- Business system and organization
- Road map for goals
- Opportunities and risks
- Financial planning and financing

2. Lectures: business analysis
Business analysis of selected business areas related to renewable resources (e.g. biogas station with CHP; effects of changed framework conditions), work on case examples

**Intended Learning Outcomes:**
After their participation, students are aware of basic requirements to set up a company. Lectures are designed to enhance business thinking. In addition, students can understand relationships in the areas of production technology and business administration relevant to companies in the field of renewable resources.

**Teaching and Learning Methods:**
Lecture (talks given by teaching staff)
Seminar (students independently study a special topic, with subsequent presentation and final report on it)

**Media:**
Presentation, excursion

**Reading List:**
Fueglistaller, Urs; Müller, Christoph A.; Volery, Thierry

**Responsible for Module:**
Hubert Röder (hubert.roeder@tum.de)

**Courses (Type of course, Weekly hours per semester), Instructor:**
Businessplan NAWARO (Vorlesung) (Vorlesung, 2 SWS)
Röder H [L], Röder H

Unternehmensanalyse und -management (Vorlesung, 1 SWS)
Röder H [L], Röder H

Businessplan NAWARO (Übung) (Übung, 1 SWS)
Röder H [L], Röder H
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

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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:
Overcoming Obstacles - the Bumpy Road toward Carbon Neutrality (Ringvorlesung Umwelt) - Garching (Vorlesung mit integrierten Übungen, 1,5 SWS)
Fahmy M, Kopp-Gebauer B, Recknagel F, Slanitz A, Zimmermann P
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

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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 groups 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:**
Overcoming Obstacles - the Bumpy Road toward Carbon Neutrality (Ringvorlesung Umwelt) - Garching (Vorlesung mit integrierten Übungen, 1,5 SWS)
Fahmy M, Kopp-Gebauer B, Recknagel F, Slanitz A, Zimmermann P
For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://campus.tum.de).
**Module Description**

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

Version of module description: Gültig ab summerterm 2022

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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:
Volker Sieber

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 summerterm 2022

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<th>Module Level:</th>
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Number of credits may vary according to degree program. Please see Transcript of Records.

Description of Examination Method:
To prove whether the students are able to understand and to describe possibilities and limitations of established industrial enzymatic processes and whether they are able to apply this knowledge 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). A bonus of 0.3 is credited on the grade of this written examination when during the module at least 65% of the exercises are marked with a positive result (yet, an increase of the grade from 4.3 to 4.0 is not possible). Thereby students shall be motivated to participate in the exercise which is very important for them.

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 resources 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:
Voker Sieber

Courses (Type of course, Weekly hours per semester), Instructor:
Enzymatic Biotransformations (Exercise) (Übung, 1 SWS)
Sieber V [L], Schmermund L

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 winterterm 2019/20

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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 machine learning 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:
Next semester

(Recommended) Prerequisites:
Basic Mathematical Skills, Basic Programming Skills

Content:
Technologies that generate analyses or predictions based on data can be found in almost all areas of our daily live (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. to predict 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 on various real-world problems.
The following contents will be treated exemplarily:
• Similarity and Distance Metrics
• Data Preprocessing and Visualization
• Classification
  o Nearest-Neighbor
  o Perceptron & Adaline
  o Logistic Regression
  o Decision Tree
o Support Vector Machines (SVM)
o Artificial Neuronal Networks
• Model Selection and Hyperparameter Optimization
o Confusion Matrix and Evaluation Measures
o Cross-Validation
o Line Search
o Over- vs. Underfitting
• Clustering
  o K-Means
  o Hierarchical Clustering
  • Regression Models
  o Linear Regression
  o Support Vector Regression

**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.

**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:**

**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

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

Version of module description: Gültig ab winterterm 2022/23

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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, a written examination takes place with a duration of 60 minutes. A bonus of 0,3 is credited on the grade of this written examination when during the module at least 65% of the exercise sheets are handed in and are marked with a positive result (an increase of the grade from 4,3 to 4,0 is not possible). Thereby students shall be motivated to participate in the tutorial which is very important for them.

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:**
Chemistry of Enzymes (Seminar) (Seminar, 1 SWS)
Sieber V [L], Al-Shameri A, Schmermund L

Chemistry of Enzymes (Lecture) (Vorlesung, 1 SWS)
Sieber V [L], Al-Shameri A, Schmermund L

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 2019/20

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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:
Next 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 learn to implement custom Python scripts to analyse, visualise and interpret 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:**

**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

CS0086: Wood-based Resources | Wood-based Resources

Version of module description: Gültig ab winterterm 2021/22

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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:
Next 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 and 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 so-called 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:**
Jörg van der Heide, 2011: Der Forstwirt. (The Forester) Publisher: Ulmer (Eugen); Auflage: 5th edition. (September 26, 2011)
Language: German
ISBN-10: 3800155702

**Responsible for Module:**
Prof. Cordt Zollfrank

**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 [MPBioTech]

Version of module description: Gültig ab winterterm 2020/21

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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 microbial biotechnological production processes, the students answer questions about production processes and fermentation strategies in a written exam (90 min, 50% weighting) and prove that they have understood the correlations of microbial metabolism. Allowed tools are calculators. The learning results in the field of plant biotechnology are going to be proved in form of a written exam (60 min., 50% weighting). In this written exam it will be evaluated to which extent the students are able to describe and assess the topics of the lecture correctly in appropriate scientific language. The seminar talk (20 Min., ungraded) will be evaluated to assess the ability of the students to correctly summarize the content of a complex scientific publication in the field of plant biotechnology and to comprehensively and convincingly present it to an audience.

Repeat Examination:
Next semester

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

Content:
Relevant topics and techniques of microbial biotechnology: - microbial metabolism (biosynthesis and degradation pathways) - industrial microbiology: production of alcohols, amino and organic acids, vitamins, antibiotics, enzymes, etc. - bioprocessing techniques - metabolic engineering strategies (e.g. optimization of precursor and cofactor availability) - quantitative biology. 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. Current topics will be discussed based on selected original publications. Some of the topics to be discussed: legal
framework, major application of current plant genetic engineering, the Arabidopsis model system, novel concepts for yield and quality improvement.

**Intended Learning Outcomes:**
Upon successful completion of the module, students will be familiar with the principles and techniques of relevant 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 and to calculate mass balances. The students have acquired in-depth knowledge of relevant production processes for selected products of industrial biotechnology. 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. Seminar: recent publications will be selected and briefly discussed with the students, then presented by the students. The presentation will be discussed and evaluated.

**Media:**
PowerPoint, whiteboard

**Reading List:**

**Responsible for Module:**
Bastian Blombach bastian.blombach@tum.de

**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

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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 understand 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:
Broder Rühmann

Courses (Type of course, Weekly hours per semester), Instructor:
Einführung in die stoffliche Nutzung / Renewables Utilization (Exercise) (Übung, 2 SWS)
Rühmann B

Einführung in die stoffliche Nutzung / 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

CS0104: Biogenic Polymers | Biogenic Polymers [Bioplar]

Version of module description: Gültig ab winterterm 2020/21

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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 be 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 research 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:**
Cordt Zollfrank

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

Biogenic Polymers (Lecture) (Vorlesung, 2 SWS)
Zollfrank C [L], Zollfrank C

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://here).
Module Description


Version of module description: Gültig ab winterterm 2020/21

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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 acquired 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:
Next 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:**

**Responsible for Module:**
Josef Kainz

**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

CS0111: Advanced Development Economics | Advanced Development Economics

Version of module description: Gültig ab winterterm 2020/21

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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:
Next 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. property 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 seminar will be done by PowerPoint. In addition, current examples from newspapers and journals will be integrated into the lectures. In the seminar, 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:**

**Responsible for Module:**
Anja Faße

**Courses (Type of course, Weekly hours per semester), Instructor:**
Advanced Development Economics (Tutorial) (Übung, 2 SWS)
Faße A [L], Faße A

Advanced Development Economics (Lecture) (Vorlesung, 2 SWS)
Faße A [L], Faße A
For further information in this module, please click [campus.tum.de](http://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 2020/21

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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:
Next 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, which forms the basis of the students' seminar papers. After the introductory session, students will work out the topic on their own, by using their abilities 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], Riesenegger L, Tuma N, Wink K, Yang X
For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://campus.tum.de).
Module Description

CS0113: Innovation in Bioeconomy | Innovation in Bioeconomy

Version of module description: Gültig ab winterterm 2020/21

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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 with a focus on bioeconomic questions and concepts. Building on a core understanding of the principles of innovation management, students will answer questions about the more recent innovation concepts that are driven by digitalization and have the ability to explain the adapted strategies and options for firms. They will also be able to assess the relevance of digital technologies and the different options to design digital business models in the context of bioeconomic questions.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Entrepreneurship, Introduction to Innovation Management

Content:
The module introduces students into advanced principles of innovation management from a digital and sustainable perspective. Students will be equipped with basic knowledge on:
- content and relevance of digital technologies
- role of ecosystems, platforms and networks
- design of business models to implement sustainable innovation
- advanced methods to generate and implement innovation
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 organising innovation in the context of digitalization by including broader economic, environmental and societal effects
- derive recommendations about the design and practices of innovation managements and how to implement sustainable innovation
- identify and evaluate digital 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:**

**Responsible for Module:**
Claudia Doblinger

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

Innovation in Bioeconomy (Lecture) (Vorlesung, 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 2020/21

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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:
Next 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:

Responsible for Module:
Prof. Dr. Anja Faße

Courses (Type of course, Weekly hours per semester), Instructor:
International Trade (Seminar) (Seminar, 2 SWS)
Faße A [L], Faße A

International Trade (Lecture) (Vorlesung, 2 SWS)
Faße A [L], Faße A ( Hering A )

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

CS0116: Markets for Energy and Biobased Products | Markets for Energy and Biobased Products

Version of module description: Gültig ab winterterm 2020/21

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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 oral examination as well as students' presentation. The students should be able to evaluate and use the taught methods of market analysis. In addition, questions related to the market development and important influencing factors on markets of energy and biobased products are discussed in the oral examination. No additional tools are allowed during oral examination. Duration of oral examination: 20 minutes. The proportion of the oral examination is 70% of the total grade.
The students' presentation 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 this presentation. Duration of presentation: 30 minutes. The proportion of the presentation is 30% of the total grade.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
Micro-economics

Content:
The content of the module comprises of theory and tools for analysing markets. This knowledge will be used to analyse the development, situation and important determinants of market development in selected energy markets and markets for biogenic products. Thereby the different markets will be regarded from raw material production over the entire value chain to the (private) consumers. In the energy field, markets for fossile raw materials (e.g. crude oil, natural gas, coal) will be considered as well as markets for regenerative energy production (e.g. wind, hydro, solar energy, use of biomass) for heating, mobility and power. In addition, selected markets for material
use of biogenic resources will be covered (like e.g. bulk chemicals, biogenic insulation materials, biogenic polymers, WPC, bioplastics, biocosmetics, detergents and cleaning material, biobased consumer products). Besides, the students will use the taught methods and tools in a students' project in which actual questions related to the market situation and development in selected markets will be analysed.

**Intended Learning Outcomes:**
After attending the module, students will be able to analyse the developments of markets as well as to select and use the adequate methods in a targeted way. Students are familiar with the relevance, size, development and important influencing factors on the energy markets as well as markets for material use of biogenic resources. They are able to independently analyse these markets, to interpret important determinants of market development, and to assess the use of fossil and regenerative energies as well as the use of biomass for material applications in a macroeconomic and societal context thus developing strategies for future use.

**Teaching and Learning Methods:**
The lecture will be done using Powerpoint with specifically worked out presentation scripts. In addition, published studies and statistical data related to the development and situation on the targeted markets will be integrated into the lectures. In the students' project, students use the taught market analysis methods and tools as well as their factual knowledge to analyse actual questions and developments on selected markets. They will present and discuss their approach and solutions with their colleagues and the lecturers.

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

**Reading List:**

**Responsible for Module:**
Prof. Klaus Menrad

**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 winterterm 2020/21

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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 oral examination as well as students' presentation. The students should be able to evaluate and use the methods of consumer and market research that were taught in the module. No additional tools are allowed during oral examination. Duration of oral examination: 20 minutes. The proportion of the oral examination is 50% of the total grade. The students' presentation 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 lecturer. Powerpoint and presentation equipment are allowed for this presentation. Duration of presentation: 30 minutes. The proportion of the presentation is 50% of the total grade.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
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 interpret 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 R or SPSS for quantitative statistical 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 colleagues and lecturers.

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

**Reading List:**

**Responsible for Module:**
Klaus Menrad

**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 2020/21

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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:
Next 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:

Responsible for Module:
Anja Faße

Courses (Type of course, Weekly hours per semester), Instructor:
Environmental Accounting in Economics and Sustainability Sciences (Lecture) (Vorlesung, 2 SWS) Faße A [L], Faße A, Voss R

Environmental Accounting in Economics and Sustainability Sciences (Exercise) (Vorlesung mit integrierten Übungen, 2 SWS)
Faße A [L], Faße A, Voss R

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 winterterm 2020/21

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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

Repeat Examination:
Next 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:**
Sebastian Georg

**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 summerterm 2022

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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

**Repeat Examination:**
Next 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:

Responsible for Module:
Prof. Sebastian Georg

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

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

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

Version of module description: Gültig ab winterterm 2020/21

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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 abilities 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
- Individual assignments and presentation

The teaching and learning methods are combined 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:
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 summerterm 2021

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Description of Examination Method:
"Term paper and presentation: 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. In the 30 minute final presentation they have to to show that they are able to summarize their findings in a scientific presentation, discuss and defend them (20' for presentation, 10' for discussion).
Weighting: Term paper 2, Presentation 1"

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 sudents 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 scientific paper, Cambridge University 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:
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

CS0128: Corporate Sustainability Management | Corporate Sustainability Management

Version of module description: Gültig ab winterterm 2020/21

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Description of Examination Method:
Achievement of desired learning objectives shall be verified in a 60 minute written final exam and a 20 minute oral presentation. The students calculate key performance indicators for sustainable management and illustrate decision-making procedures and alternatives based on case studies. They show that they are able to outline and explain business processes of sustainable management. They demonstrate that they are able to answer questions on sustainable management in their own words. The oral presentation shall be assessed according to content and rhetoric aspects. 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:
-

Content:
The module of sustainable management includes a detailed discussion about the term of sustainability (four-pillar model) and its historical development. Basic premises for sustainable management or sustainable development shall be derived from it and discussed in the social, political, economical and business context. National, European and international strategies for sustainable economics shall be introduced (e.g. Bioeconomy, Circular Economy, Green Economy, Agenda 21). Furthermore current measuring concepts and key performance indicators for sustainability (e.g. resource productivity, life cycle costing) shall be treated and applied to exemplary products and value chains and discussed in the framework of "corporate social responsibility reporting".
**Intended Learning Outcomes:**
After having participated in the module the students are able to understand sustainability concepts and to compare sustainability-oriented corporate images as a supplement to value added oriented corporate images. They are able to perform sustainability assessments based on current measuring concepts and key performance indicators. They are able to represent products and services within the scope of sustainable forms of economy.

**Teaching and Learning Methods:**
The module consists of a lecture and an exercise. During the lectures the contents are delivered by presentations and discussions. The lectures are used to convey the theoretical 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. Students deepen their understanding through working in small student groups as well as solving exercises on their own.

**Media:**
Presentations, slide scripts

**Reading List:**

**Responsible for Module:**
Hubert Röder

**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](http://campus.tum.de) or [here](#).
Module Description

CS0169: Sustainable Supply Chain Management | Sustainable Supply Chain Management

Version of module description: Gültig ab winterterm 2021/22

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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:
Next 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 tuition using beamer, overhead projector, flipchart

Reading List:
Cachon/Terwiesch (2012): Matching Supply with Demand

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

CS0170: Advanced Modelling and Optimization | Advanced Modelling and Optimization

Version of module description: Gültig ab winterterm 2021/22

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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, applying algorithms to solve problems, creating mathematical models for exemplary 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:

(Recommended) Prerequisites:
Operations Research (CS0098)
Content:
This course is about modeling, solving and analyzing planning and decision problems using mathematical 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:
Popp, Andreas: Modellierung und Optimierung mit OPL. epubli, 2015

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 summerterm 2022

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 taught 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:
Next 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 taught 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:
Prof. Klaus Menrad

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

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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:
• 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], Wink K, Winkler T

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 2021/22

<table>
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<th>Module Level:</th>
<th>Language:</th>
<th>Duration:</th>
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<tr>
<td>Master</td>
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<td>one semester</td>
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<td>135</td>
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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:
Next 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:**

**Responsible for Module:**
Alexander Hübner

**Courses (Type of course, Weekly hours per semester), Instructor:**
Discrete Event Simulation (Lecture) (Vorlesung, 2 SWS)
Hübner A [L], Schäfer F
Discrete Event Simulation (Exercise) (Übung, 2 SWS)
Hübner A [L], 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

<table>
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<th>Module Level: Bachelor/Master</th>
<th>Language: English</th>
<th>Duration: one semester</th>
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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

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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 spreadsheets 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:

Responsible for Module:
Magnus Fröhling
Courses (Type of course, Weekly hours per semester), Instructor:
LCA Case Studies (Seminar, 3 SWS)
Fröhling M [L]. Fröhling M, Lohmeyer R
For further information in this module, please click campus.tum.de or here.
Module Description

CS0228: Technology and Management of Renewable Energies in Africa and the EU | Technology and Management of Renewable Energies in Africa and the EU [REAE]

Version of module description: Gültig ab summerterm 2021

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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 (30 minutes) and a short report of the students' project work. 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 Africa or in the EU. 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 country context. The presentation will be passed over to the lectureres as well as the short report and will be included in the grading.

Repeat Examination:
Next 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

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 in the EU and in Africa (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 in the EU and in Africa. Thereby 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 a country of the EU or in Africa into account when analysing and elaborating solutions for the question on-hand. They are able to apply their knowledge to create an oral presentation. 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 (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:
Prof. Dr. Klaus Menrad

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

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<th>Module Level:</th>
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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:

(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 policies. 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:**
Bibliography of scientific publications

**Responsible for Module:**
Andreas Pondorfer

**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

CS0244: Inventory and Transportation Management

Version of module description: Gültig ab winterterm 2021/22

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<th>Module Level: Master</th>
<th>Language: English</th>
<th>Duration: one semester</th>
<th>Frequency: winter semester</th>
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<td><strong>Contact Hours:</strong> 60</td>
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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:
Next 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:
Günther, H.O., Tempelmeier, H. (2020), Supply Chain Analytics

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

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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:**
- Alberto Bisin and Giovanni Federico (2021), The Handbook of Historical Economics, Academic Press
- Bibliography of scientific publications

**Responsible for Module:**
Andreas Pondorfer (andreas.pondorfer@tum.de)

**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](http://campus.tum.de) or [here](http://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 winterterm 2022/23

<table>
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<th>Module Level: Master</th>
<th>Language: English</th>
<th>Duration: one semester</th>
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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’ presentation.
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: 45 minutes. The proportion of the written examination is 50% of the total grade.

The students' presentation 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 this presentation. Duration of presentation: 20 minutes. The proportion of the presentation is 50% of the total grade.

Repeat Examination:

(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. Sawtooth).

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:
- Sawtooth manuels

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)
Decker T [L], Decker T, Pondorfer A
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

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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:

(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:**
• Shin, Hyun Song (2019) Risk and Liquidity, Claredon Lectures in Finance
• Selected publications from Basel Committee on Banking Supervision, ESAs, EPCC, WMO.
• 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

**Responsible for Module:**
Viktoriia Shkola (viktoriia.shkola@tum.de)

**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](http://campus.tum.de) or [here](http://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 winterterm 2022/23

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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
- Circularity Gap Report Global (2022); https://www.circularity-gap.world/2022
- Lewrick, Michael : Design Thinking for Business Growth: How to Design and Scale Business Models and Business Ecosystems (2022), Wiley
- 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.un.org/sustainable-development-goals/
  utm_source=EN&utm_medium=GSR&utm_content=US_UNDP_PaidSearch_Brand_English&utm_campaign=Go
glVhuJ3Ch3pVQtFEAAYAyAAEgLnGvD_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
  Humanity (2022), New Society Publishers

**Responsible for Module:**
Prof. Magnus Fröhling

**Courses (Type of course, Weekly hours per semester), Instructor:**
Case study driven seminar on Sustainability and Innovation Management in an Industrial Context
(Seminar, 2 SWS)
Fröhling M [L], Fröhling M

Sustainability and Innovation Management in an Industrial Context (Vorlesung, 2 SWS)
Fröhling M [L], Fröhling M

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://here).
Module Description


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

Version of module description: Gültig ab summerterm 2021

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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:

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 the successful participation in the module, the students are able to:
- examine the relevance of a problem and develop a solution collaboratively in an interdisciplinary team.
- to discover the innovation potentials of new products/ideas, to evaluate the novelty and social relevance.
- To convert one’s own ideas into a Minimum Viable Product and thus use potentials for one’s own business start-up.
- To know methods of product development (from thinking to doing), to apply them independently and to evaluate the results (prototyping, design thinking, lean startup, agile, systems engineering).
- to reproduce the principles of user-centred design, to apply them independently and to evaluate them.
- Understand the context of use and analyse customer needs (where do I serve a need and what technology/method do I use).
- To quickly develop important hypotheses involving relevant stakeholders (customer, user, ...) through proper Planning with "purposeful prototyping".
- Change perspectives across disciplines and apply project management in interdisciplinary teamwork.
- To work independently, to make and justify decisions and to learn from one's own mistakes.
- To possibly 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:**


Kelly, Tom (2016): The Art of Innovation

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

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


Ries, Eric (2011): The Lean Startup

Savoia, Antonio (2019): The right It


**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], Martins Pacheco N, Tong Y, Reif M, Bandle M, Baur C, Thies A, Hohnbaum K, Schmid F, Büchner B
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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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 reexamine 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, participants 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):


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

Courses (Type of course, Weekly hours per semester), Instructor:
Advanced Seminar Economics & Policy: Decisions under Uncertainty from Description and from Experience (Seminar, 4 SWS)
Kopsacheilis O
For further information in this module, please click campus.tum.de or here.
Master's Thesis | Master's Thesis

Module Description

CS0115: Master's Thesis | Master's Thesis [MT BEC]

Version of module description: Gültig ab winterterm 2020/21

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

Description of Examination Method:
The module examination consists of the preparation and positive evaluation of the Master's Thesis (approximately 25 to 100 pages, depending on the topic). The overall grade is determined by the grade of the Master's Thesis.

Repeat Examination:
Next semester

(Recommended) Prerequisites:
60 credits in compulsory and elective modules of the master's program Bioeconomy

Content:
Deepening the knowledge of current academic literature on a specific topic, which can be freely chosen from the Bioeconomy program in consultation with the supervisor. Deepening the knowledge of appropriate research methods, as well as gaining experience in their application.

Intended Learning Outcomes:
After completing the module, students are able to derive complex scientific questions and to work on them independently using adequate scientific methods. In doing so, they demonstrate their ability to think analytically on their own. They are able to present their results conclusively, discuss them, and draw final conclusions.

Teaching and Learning Methods:
First, together with the supervisor, the topic is the topic is narrowed down and a research question is developed. Within the framework of the Master's Thesis, the students work on this scientific question. Among other things, literature
research, theoretical models and/or empirical methods are applied. The actual teaching and learning methods depend on the respective research question and are decided jointly with the supervisor in each individual case.

**Media:**
Academic literature, software, etc.

**Reading List:**
in consultation with the supervisor

**Responsible for Module:**
Alle prüfungsberechtigten Dozenten/innen des Studienganges Bioeconomy

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

For further information in this module, please click [campus.tum.de](http://campus.tum.de) or [here](http://www.tum.de).
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