Technische Universität Braunschweig

Modules of the degree program

Battery and Hydrogen Technology (Master)
PO 1

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Compulsory Modules

Title	Future Battery Production Systems
Number	2521000070
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: written exam (90 min) or oral exam (30 min)
Course achievement	presentation (10 min)
Objective qualification	
Upon completion of the module, students will be able to: • Demonstrate foundational knowledge of the battery lifecycle and next-generation batteries, as well as analyze complex questions related to these topics. • Critically analyze and address current research questions regarding the battery lifecycle. • Work effectively in a team and, if necessary, provide guidance. • Identify complex problems and develop structured approaches to solutions. • Independently acquire and apply new complex knowledge. • Process, present, and communicate results in various goal-oriented ways.	

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Title	Hydrogen as Future Energy Carrier
Number	2536000010
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: written exam (90 min) or oral exam (30 min)
Course achievement	
Objective qualification	
The lecture covers the mobility topic of hydrogen and hydrogen as an energy carrier of the future. Through participation, students are enabled to explain the fundamental aspects of the hydrogen cycle economy and to apply objective criteria to its ecological implementation in the transport sector. They are able to specify the basic physical as well as chemical properties of hydrogen. Moreover, students can independently apply thermodynamic properties along with the associated kinetic and efficiency calculations. They can analyze and explain both established and emerging storage forms for hydrogen. They are also capable of evalua-	

ting the advantages and disadvantages of hydrogen use compared to battery-electric propulsion in automobiles and of drawing a comparison with alternative hydrogen combustion. Based on this knowledge, they can determine which option is energetically more favorable. Through in-depth discussions, students become sensitized to safety-relevant issues related to hydrogen as an energy carrier and can develop and assess appropriate safety concepts.

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Title	Modern Modelling and Artificial Intelligence
Number	2521000090
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: Written exam (90 min) or oral exam (30 min)
Course achievement	1 course achievement: Development and documentation of AI models

Objective qualification

Upon completion of the module, students will have a solid understanding of key methods of modern machine learning and artificial intelligence. They will be able to categorize and describe fundamental learning paradigms, model classes, and current AI architectures such as hybrid modeling approaches, graph attention networks, transformer models, diffusion models, and mixture of experts, and evaluate their suitability for process engineering applications. Based on the theoretical and practical knowledge they have gained, they will be able to select suitable data-driven and hybrid methods, assess their robustness and uncertainties, and implement them using Python. Students will be able to analyze real data sets, develop and validate models, and combine and further develop different approaches in a meaningful way in order to independently solve complex process and system modeling tasks.

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Elective Modules

Title	Additive Layer Manufacturing
Number	2510300
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: written exam, 120 minutes or oral exam, 30 minutes
Course achievement	
Objective qualification	
After completing the module, students can select the most appropriate 3D printing technology and respective materials to manufacture parts by 3D printing. Furthermore, they are able to plan and execute the whole process chain, starting with CAD model and finishing with real, ready-to-use parts. They can select appropriate post-processing steps, surface preparation and surface treatments. Student are capable to steer the part-designing process to increase printability success, reduce material waste and post-processing time. With the taught knowledge of Additive Manufacturing and topology optimization, students are able to create sophisticated, topology-optimized models or re-design existing ones.	

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Title	Advanced Fluid Separation Processes
Number	2541430
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: Written exam, 90 minutes or oral examination 30 minutes
Course achievement	
Objective qualification	
The students know the characteristics of the integration of reaction and separation. The processes of chemisorption, reactive distillation, reactive extraction (absorption and adsorption), chromatography, drying and membrane technology are known. Advantageous applications can be identified. Process design under operational and economical aspects and the implementation of equipment can be designed quantitatively. Students are able to elaborate and communicate these topics orally and in written form in english language.	

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Title	Instrumental Analysis and Testing in Surface Technology
Number	2525030
ECTS	5,0
Compulsory requirements	Knowledge of differential and integral calculus, elementary understanding of physical relationships
Compulsory attendance	
Expected performance/ Type of examination	1 Examination element: written exam (90 min) or oral exam (30 min)
Course achievement	
Objective qualification	
Students can apply the analytics and characterization of surfaces and thin. Students can use the knowledge of bachelor-level physics to multiple examples of practical importance.	

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Title	Application of Commercial FE-Software
Number	2529010
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: written exam (120 min) or oral exam (60 min) in groups
Course achievement	
Objective qualification	
After completing the module attendees will be able to describe calculations that run in the background of commercial FE software and to display results graphically. Students are able to solve given problems independently in computer exercises. They can select and justify settings of commercial FE-tools and evaluate the strength of structures.	

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Title	Characterisation of Surfaces and Thin Films
Number	2525210
ECTS	5,0
Compulsory requirements	
Compulsory attendance	

Expected performance/ Type of examination	1 examination element: written exam (90 min) or oral examination (30 min)
Course achievement	
Objective qualification	
After finishing the module students can describe commonly used methods applied for characterizing mechanical, electrical, optical and wetting properties of thin and ultrathin films. They are able to select methods for measuring thickness, topography, composition and inner structure of surfaces and thin films.	

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Title	Computer Aided Process Engineering 1 (Introduction)
Number	2541500
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	2 examination elements: 1. term paper on simulation applications (to be weighted 2/5 in the calculation of module mark) 2. written exam (60 min) or oral exam (30 min) (to be weighted 3/5 in the calculation of module mark)
Course achievement	
Module grade composition	2 examination elements: 1. term paper on simulation applications (to be weighted 2/5 in the calculation of module mark) 2. written exam (60 min) or oral exam (30 min) (to be weighted 3/5 in the calculation of module mark)
Objective qualification	
Students can select physical property and phase equilibrium information, which are needed for modelling and simulation of fluid separation processes, especially vapor-liquid based separations. They are able to distinguish and weigh between parameters in addition to create a physical property data file. For a given process flow sheet or separation problem they are able to develop an appropriate reflection in a flow sheet simulation based on the equilibrium stage model. For selected equipment types, such as heat exchangers and distillation columns, they are able to perform a cost-optimum selection and sizing. Overall, they know the typical workflow for fluid process design in the framework of Computer Aided Process Engineering. Students are able to communicate and deliver the above in English language orally and in writing.	

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Title	Computer Aided Process Engineering 2 (Design of Process Plants)
Number	2541270
ECTS	5,0
Compulsory requirements	
Compulsory	

attendance	
Expected performance/ Type of examination	2 Examination elements: 1. written exam (90 min) or oral exam (30 min) (to be weighted 3/5 in the calculation of module mark) 2. presentation of a lecture accompanying project (to be weighted 2/5 in the calculation of module mark)
Course achievement	
Module grade composition	2 Examination elements: 1. written exam (90 min) or oral exam (30 min) (to be weighted 3/5 in the calculation of module mark) 2. presentation of a lecture accompanying project (to be weighted 2/5 in the calculation of module mark)
Objective qualification	
The students can explain the basic process steps in development and design of a typical processes. They know and are able to gather the required information for the design of a process plant (material, safety-related, reaction-related, etc.) and can derive this information from suitable sources. Using a process simulation tools they are able to conceive a quantitative process design. They can select suitable designs for the main apparatus (e.g. heat exchangers, columns) and dimension them according to requirements. Taking into account logistical and safety aspects, they can prepare a plant design and present it in a suitable form.	

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Title	Data Science in Fluid Mechanics
Number	2512000080
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: Homework with presentation
Course achievement	
Objective qualification	
With the aid of several applied exercise sessions using MATLAB, the students can classify and quantify the various types of uncertainties and their propagation. The students are capable to identify and quantify the main sources of these uncertainties and of reducing them. Using Tecplot software, the students can visualize fluid flows using different approaches and identify the best one to extract the most visual information from flow snapshots. By learning and applying various spectral-decomposition techniques, the students can identify the most relevant and dominant modes and physically interpret them. Using real numerical and experimental data and implementing different uncertainty and spectral analysis methods, the students are exposed to realistic scientific data-analysis scenarios that enable them to investigate and extract the most relevant physical information from any fluid flow data.	

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Title	Digital Electronics
Number	2538090

ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	written exam (120 min) or oral exam (30 min)
Course achievement	

Objective qualification

Students are able to apply number systems and Boolean algebra and analyse the results. They can transfer methods for simplifying electronic circuits and data processing to previously unknown application examples. Furthermore, they are able to select and use different methods for the theoretical and practical realization of logic, toggle, counter and calculation circuits according to their needs. They can describe, apply and examine the production of printed circuit boards.

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Title	Digital Technologies in Process Engineering
Number	2541450
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	written exam (90 min) or oral exam (30 min) - presence or digital
Course achievement	

Objective qualification

Lecture:
Students will be able to explain and differentiate the essential terms in the context of digitization and Industry 4.0. They can define and explain methods of machine learning and apply known procedures. Students can argue which method would be suitable for a given problem. They know the general procedure of data analysis and can describe and apply known algorithms. The algorithms used can be analyzed and evaluated with regard to their prediction accuracy. Typical model errors can be identified and evaluated by the students.
Exercise: The students are able to abstract the acquired knowledge to practical examples. They can select and apply the programming environment necessary for data preparation and visualization as well as familiar tools. Students can program and execute simple algorithms for statistical data analysis and machine learning. Furthermore, the students are enabled to work successfully in a group, to communicate efficiently and to develop solutions independently. By working with other people (group members, supervisors) this promotes the students in their communication skills and social competence.

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Title	Energy Efficiency in Production Engineering

Number	2522930
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	written exam+ (120 min) or oral exam+ (30 min)
Course achievement	presentation and/or written report in the context of a teamproject (On application, the result of the course achievement is taken into account in the assessment of the written examination+ or of the oral examination+, respectively, and can account maximum 20% of the respective grade.)

Objective qualification

The students...
- ... explain the planning, design and development of sustainability-oriented production systems in different contexts
- ... assess different strategies (e.g. efficiency strategy) and principles (e.g. avoidance principle) of sustainable development in defined use cases on a laboratory scale
- ... evaluate existing production systems in economic, ecological and social dimensions
- ... are able to illustrate the results of various efficiency strategies to non-experts and to apply relevant assumptions, restrictions and framework conditions correctly
- ... design their own research questions within the team project, evaluate experiments and derive a presentation of the results of the research
- ... organize themselves in a team project and gain experience in relevant soft skills such as teamwork, communication and presentation skills
- ... analyze sustainability-oriented production systems within a given topic
- ... are able to select relevant fields of action and measures for sustainable production

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Title	Energy Turnaround – Industrial Hydrogen Applications
Number	2521000010
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	written exam (90 min) or oral exam (30 min)
Course achievement	

Objective qualification

Students will gain knowledge in the field of H2 generation, economics, storage, transport and utilization. After completing the lecture and exercise, the students will be able to name possible applications of H2 and describe the general interrelationships along the entire value chain, recognize the relevance of H2 on the

path to climate neutrality by 2030, name and explain relevant technologies in the context of hydrogen, as well as discuss and reflect on essential characteristics regarding the transformation of the energy sector.

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Title	Formulation Technology for Components of Battery and Hydrogen Systems
Number	2521000110
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: Written exam (90 min) or oral exam (30 min)
Course achievement	

Objective qualification

In this module, students acquire in-depth engineering and scientific skills enabling them to reliably design, apply and evaluate recipes, processes and procedures for the process engineering manufacture of components for battery and hydrogen systems. In addition to in-depth fundamentals, they learn to classify current trends and research results, design suitable unit operations, processes and production methods, and systematically solve complex challenges. They also develop the ability to flexibly transfer their knowledge to industrial applications in the battery and hydrogen sector.

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Title	Fuel Cell Systems
Number	2536230
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: written exam (90 min) or oral exam (30 min)
Course achievement	

Objective qualification

The lecture deals with the future-relevant topic of fuel cell systems. By participating, students will be able to outline a production cycle of the individual components and set objective standards for its ecological realisation in the mobility sector. They are able to name the basic physical and chemical properties of the components. The students are able to independently apply thermodynamic properties and related kinetic calculations as well as efficiency calculations. The students are able to explain and analyse the forms of special fuel cells (systems) in addition to the established formats. The students are able to assess the advantages and disadvantages, especially in relation to the battery-electric drive in the mobility sector, and also the comparison with the combustion of hydrogen can be analysed and distinguished which form is energetically more

favourable. Detailed discussions of relevant system aspects are described by the students and thus round off the qualification objectives.

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Title	Ceramic/Polymer materials
Number	2524120
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	2 examination elements: a) ceramics: written exam (60 min) or oral exam (20 min) (to be weighted 1/2 in the calculation of module mark) b) polymers: written exam (60 min) or oral exam (20 min) (to be weighted 1/2 in the calculation of module mark)
Course achievement	
Module grade composition	2 examination elements: a) ceramics: written exam (60 min) or oral exam (20 min) (to be weighted 1/2 in the calculation of module mark) b) polymers: written exam (60 min) or oral exam (20 min) (to be weighted 1/2 in the calculation of module mark)
Objective qualification	
The students are able to list the different technical porcelains, ceramics and polymers (thermoplasts, elastomers and duromers) and can describe their chemical, physical and mechanical properties. The students are able to classify a non-metallic material (with respect to the classes given above). The students are able to name the different production chains for ceramic materials and polymers und explain which production process should be applied to produce a dedicated component. The students are able to name, understand and analyse the design principles for ceramic materials at component examples. The students are able to perform a correct selection of a non-metallic material for a given application. The students understand which non-metallic material can be used for a given application and are, therefore, able to work with these materials in their future jobs.	

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Title	Life Cycle Assessment for Sustainable Engineering
Number	2545020
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	written exam+ (120 min) or oral exam+ (30 min)
Course achievement	presentation and/or written report in the context of a teamproject (On application, the result of the course achievement is taken into account in the assessment of the writ-

	ten examination+ or of the oral examination+, respectively, and can account maximum 20% of the respective grade.)

Objective qualification

Students...
- are able to conduct a Life Cycle Assessment (LCA) according to the ISO 14040/14044 standard
- are able to analyze an existing LCA study regarding the strength of its results and potential weaknesses of the study
- communicate LCA results to laypeople, and include relevant assumptions, limitations and boundary conditions in their communication
- know the modeling choices which need to be made as part of a LCA, and what should inform their decisions regarding these choices
- are able to identify, comprehend, refine and present relevant information regarding a given topic within the domain of LCA
- can, provided with adequate data, use LCA software to produce meaningful LCA results
- know how to organize themselves within a group project, which includes effective communication, sharing of workloads and the timely completion of tasks

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Title	Material Cycles of Energy Storage Systems and Converters
Number	2521000060
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: written exam (90 min) or oral exam (30 min)
Course achievement	

Objective qualification

Students will gain knowledge of the extraction of raw materials and the processing of materials into components for the production of energy storage systems and converters. On the one hand, the focus is on the different countries in which raw materials are extracted, the processes of raw material extraction (including mining), the traceability of materials (traceability, transport chains) and the processing methods to produce suitable materials for energy storage systems and converters. On the other hand, the focus is on the return of materials from use, i.e. at the end of their life cycle. Different recycling processes (dismantling, mechanical, thermal, hydro- and pyrometallurgical treatment processes) and the subsequent return of the recycled materials to production processes of lower, equal or higher value are covered.
Upon completion of the lecture and the tutorial, students will be able to: identify mining, production and recycling processes and describe the general interdependencies along the entire value chain; recognise the importance of raw material recycling and traceability of raw materials along the supply chain; identify and explain relevant technologies; and discuss and reflect on key characteristics of factors influencing the transformation of the energy sector.

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Title	Methods of Process Modelling and Optimization
Number	2520460
ECTS	5,0

Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 Examination element: Written exam (120 min) or oral examination (30 min)
Course achievement	1 Course achievement: Project portfolio for the team project
Objective qualification	
Students can explain the differences between deterministic physical, empirical and stochastic modeling. They are able to analyze process engineering, chemical and biotechnological processes and select suitable model approaches for answering specific questions. Students know different types of empirical process models and can apply them to calculate model parameters based on given data. They can also design and analyze stochastic models for simple example systems. Students can independently develop physical models from a process description and use them to evaluate and optimize processes. Furthermore, they can implement the models in the Matlab software and analyze and interpret the simulation results.	

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Title	Microscopy and Particle Measurement in Micro- and Nanoscale
Number	2521080
ECTS	5,0
Compulsory requirements	none
Compulsory attendance	
Expected performance/ Type of examination	1 Examination: written exam (90 min) or oral exam (30 min)
Course achievement	
Objective qualification	
After completing the module, students will be able to describe the setup and operation of optical microscopes and explain the relationship between beam path and image generation or contrasting. Based on this, they will be able to select suitable microscopic techniques and parameters for biological as well as technical applications. The students are able to sketch the setup of electron microscopes and explain the functionalities of the individual modules. They will be able to reproduce the individual interactions that occur when electrons strike matter and link them to the various detectors of the instrument. Students will know the requirements for electron microscopic specimens and be able to select appropriate preparation techniques. Students will be able to explain the function of all common methods for particle size analysis and will be able to derive criteria for selecting a measurement method based on the material system under investigation. They will be able to convert obtained particle size distributions and calculate characteristic values. The students know the construction and the mode of operation of selected scanning probe microscopes (STM and AFM) and can explain different measuring modes. They are able to critically evaluate measurement results and interpret the results. The students are able to prepare and present work results in groups.	

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Title	Modeling and Simulation of hydrogen-based Energy Systems
Number	2519000020
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: oral exam (30 min) or written exam (120 min)
Course achievement	

Objective qualification

Students will#...

- gain a comprehensive understanding of hydrogen-based energy systems and their dynamic operation.
- gain an overview of relevant fluids in hydrogen-based energy systems (including hydrogen and possible derivatives, relevant reactants and products, heat transfer fluids), their thermophysical properties, and ways to incorporate these properties into system simulation models.
- gain an overview of relevant balance equations and transport processes (especially heat and mass transport) and their representation in system simulation models.
- gain an overview of relevant components of hydrogen-based energy systems and their operating principles.
- are able to create and parameterize complex system models based on system flowsheets using existing building blocks (e.g., component and subsystem models) and implement associated control loops.
- are able to answer given questions using the system models and independently derive further questions.
- are able to critically evaluate the simulation results generated and derive optimization measures for the system and its dynamic operation (e.g., with regard to performance, efficiency, and operating strategy).
- are able to prepare and document the simulation results in a suitable manner, both graphically and in text form.

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Title	Modern Batteries for BHT
Number	2520000020
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: written exam (90 min) or oral exam (30 min)
Course achievement	

Objective qualification

With regard to energy storage in batteries, students acquire knowledge of the thermodynamic and kinetic fundamentals necessary to understand and describe electrochemical reactions happening at electrode-elec-

trolyte interfaces. They become familiar with the key concepts and approaches of electrochemistry as well as important aspects of materials science and engineering, and learn how these are applied in selected applications, e.g., for lithium ion batteries. Furthermore, students gain the knowledge required to characterize materials and electrodes using selected, appropriate methods, enabling them to identify and optimize new materials and processes for modern batteries.

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Title	Molecular Simulation
Number	2519060
ECTS	5,0
Compulsory requirements	none
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: wtitten exam (90 min) oral exam of (30 min)
Course achievement	

Objective qualification

After completing this course, the students are able to explain the fundamental physical concepts of molecular simulation and of the derived simulation algorithms. They can evaluate different simulation techniques and concepts of molecular modelling regarding their applicability for different simulation tasks. With the gained knowledge, the students are able to perform both Monte Carlo and molecular dynamics simulations, and to analyse the simulation output to derive thermophysical and structural properties. They have acquired the skills to deepen their knowledge in a student's thesis in this field.

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Title	Numerical simulation of reactive flows
Number	2518000000
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	2 Examination elements: 1. written exam (90 min) or oral exam (30 min) (to be weighted 3/5 in the calculation of the module grade) 2. written report on simulation applications (to be weighted 2/5 in the calculation of the module grade)
Course achievement	
Module grade composition	2 Examination elements: a) Oral exam, 30 Minutes or written exam, 90 Minutes (to be weighted 3/5 in the calculation of the module grade)

	b) Written report on simulation applications (to be weighted 2/5 in the calculation of the module grade)

Objective qualification

Attending the course, the students will be able to:
- compute thermophysical properties and chemical kinetics of gas mixtures;
- understand fundamentals of the finite-volume method;
- generate meshes of simple geometrical configurations;
- perform 1D and 2D simulations of reacting flows;
- perform serial and parallel simulations;
- evaluate the results in a critical way by visualization and postprocessing flow features.

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Title	Numerical Methods of Differential Equations
Number	2543020
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: written exam (90 min)
Course achievement	

Objective qualification

The students are able to
1. name different solution strategies for solving differential equations.
2. explain the differences between the existing methods using a given example.
3. select suitable solution methods for given case studies.
4. calculate solutions of example problems with the a forementioned solution methods.
5. evaluate the calculated results based on reference solutions.
6. describe the validity limits of their solutions on the basis of the underlying assumptions and derive possible improvements.

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Title	Numerical Simulation (CFD)
Number	2520140
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/	1 Examination element: Written exam (90 min) or oral examination (30 min)

Type of examination	
Course achievement	

Objective qualification

The students acquire a deeper knowledge of the mathematical principles of discretization and the numerical solution of the system of balance equations of technical flows and are able to explain them. They are able to establish physical connections to the discretization methods from the conservation equations and to classify the basic concepts of numerical methods. The students are able to name and explain the basic requirements for the use of numerical methods in practice. The students learn to apply appropriate models to solve complex flow problems and to evaluate the quality of computer simulations based on these models.

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Title	Orientation Services Management
Number	2201000000
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 portfolio or 1 take-home exam
Course achievement	for Organization, Governance, Education / MA Social Sciences instead of the examination performance: 1 portfolio or 1 take-home exam

Objective qualification

Depending on the selected courses:

After successful participation, students will have a basic understanding of brands and knowledge of which aspects play a role in branding. In addition, they will understand and be able to critically discuss how brands are developed and positioned and which instruments are suitable for this. They can argue on the basis of theory why certain brand-related measures can be expected to have an effect and have methodological knowledge in order to measure the brand and quantify influencing factors. Students will be able to formulate precise problems and research questions based on a complex practical issue in the field of brand management and develop a solution to the problem using the content and methods learned in the lecture.

After successful participation, students have a basic understanding of business model innovation and know which factors play a role in the development of business model innovations. In addition, they will understand and be able to critically discuss how innovations are developed and which methods are suitable for this. They can argue on the basis of theory why certain corporate measures can be expected to have an effect on the success of innovation and have methodological knowledge to develop, evaluate and critically reflect on business model innovations themselves. Students can formulate precise problems and research questions based on a complex practical issue in the field of innovation management and develop solutions to problems using the content and methods learned in the lecture and taught in the exercise.

Students have an understanding of issues that arise in the context of recording, designing and evaluating customer relationships. Based on the concepts and methods they have learned, students will be able to independently record, conceptually structure and analyze customer relationship management issues in various industry contexts. They have methodological and application knowledge for the qualitative and

quantitative analysis of customer and company data required to answer customer relationship management tasks.

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Title	Process Technology of Nanomaterials
Number	2521500
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: written exam (90 min) or oral exam (30 min)
Course achievement	
Objective qualification	
After completion of this module, the students possess comprehensive knowledge about nano-materials and their process technologies for engineering of nanomaterials: They are able to define different categories of nanomaterials and nanoparticles, and explain the properties and benefits of nanomaterials for various applications. The students are capable of describing different production processes (specifically comminution, gas- and liquid-phase synthesis) and applying optimizations to these processes.	

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Title	Production Technologies for Electromobility
Number	2522540
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 Examination element: Written exam (120 min)
Course achievement	
Objective qualification	

Students are able to
#
- differentiate the specific components of an electric car from the components of a conventional car #
- deduce the effects of new components on the supply chains of the OEM and the automotive suppliers #
- plan basic production processes for the electric drivetrain taken into consideration the challenges in production technologies for electric vehicles #
  identify potentials for optimisation of assembly and disassembly of traction batteries #
- assign tasks in assembly according tot he qualification of the employees #

- name new production technologies for lightweight construction an the electric power unit, assign them to the correct position in the process chain, identify safety relevant tasks and take risk-reducing measures #
- work in multi-disciplinary teams

↑

Title	Plant and Process Safety
Number	2541460
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: written exam (90 min) or oral exam (30 min)
Course achievement	

Objective qualification

On completion of this module, students have knowledge of the safe and environment-friendly manufacture of chemical products. They have a basic knowledge of the recognition and assessment of hazards, building on a methodical approach to risk management. They can identify potential hazards based on systematic process and plant considerations and mitigate them through various plant safety measures. The students know the basic laws, ordinances and technical rules on plant safety. They acquire knowledge of the safe and competent handling of hazardous substances and of the fundamentals of technical fire and explosion protection.

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Title	Separation and Purification of Energy Carriers
Number	2541000000
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	written exam (90 min) or oral exam (30 min)
Course achievement	

Objective qualification

The students are able to elaborate on the fundamentals of common unit operations used for separation and purification of energy carriers. They know the fundamental working principles, basic engineering and design methods and are able to select suitable unit operations based on mixture properties (composition, product specification) the separation task. They can work out a conceptual process and equipment design for a given separation task. Furthermore, the students know about common analysis methods, are able to elabo-

rate on the underlying working principles and select suitable methods for a given mixture. Students are able to communicate their approach, rational and results in written and oral form.

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Title	Numerical Methods in Particle Technology
Number	2521390
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 Examination: written exam (90 minutes) or oral exam (30 minutes)
Course achievement	1 course achievement: Participation at the practical simulation course.

Objective qualification

After completing the module, students are able to classify the simulation methods taught in this course into the appropriate size and time scales. They can name the models on which the simulation methods are based and discuss their applicability to real problems in particle technology. Furthermore, they are able to describe schematically the processes and algorithms involved in the implementation of the taught simulation methods. They can independently apply the concepts of the discrete element method to their own problems. They have the ability to analyze the influence of input variables on given force models by means of calculations. Various force and potential curves can be described by the students by means of sketches. The students are also able to name the terms of given basic equations in numerical fluid mechanics, CFD-DEM coupling and population balance methods in the context of particle simulation and to explain their meaning.

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Title	Smart Sensing in Fluid Dynamics
Number	2512000110
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination elemnt: oral exam (30 min) (to be weighted with 30% in the calculation of module mark)
Course achievement	2 course achievements: a) Lab report (to be weighted with 40% in the calculation of module mark); b) project presentation (to be weighted with 30% in the calculation of module mark)

Objective qualification

By attending the module, students will be able to:
- Understand the physical principles, advantages, and limitations of state-of-the-art and emerging measurement techniques
- Gain hands-on experience with related experimental methods and setups

- Work with cutting-edge experimental tools to capture high-fidelity data
- Learn best practices for equipment calibration, data acquisition, and signal pre-processing
- Develop expertise in advanced post-processing methods, including spectral analysis, modal decomposition, and uncertainty quantification and error analysis
- Use advanced data treatment techniques including sparse reconstruction, data assimilation and multi-fidelity sensing

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Title	Specialisation Law
Number	2216360
ECTS	5,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 exam (120 min) or 1 take-at-home exam
Course achievement	for Organisation, Governance, Education / MA Social Sciences instead of the examination: 1 written exam (120 min) or 1 take-at-home exam

Objective qualification

The courses teach the following theoretical legal content in order to enable graduates to independently identify the relevant legal standards in their respective specialist area and to make subject-related legal decisions taking into account the current legal situation and to present these in a scientific and practice-oriented manner in writing and orally. Only the application-orientated integrative consideration of legal requirements and technical processes enables legally compliant company/product/production design (compliance).

After completing the module in the Public Law specialisation, students will be able to independently deal with the specialist laws in energy law and identify relevant legal norms. Here, technical examples from other lectures are taken up and jointly assessed on the basis of the existing legal situation. They will also learn the sector-specific "state of the art" with examples from technical practice.

After completing the module in the specialisation Civil Law, students will be able to independently find the specialist laws and relevant standards relevant to them and solve legal issues in public procurement law, patent and trademark law and/or IT security law by working with the law. After completing the module, students are sensitised to the content of the lectures in order to be able to participate in public procurement procedures and are sufficiently qualified to ask the right questions in practice in the context of patent and trademark law procedures.

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Title	Materials engineering for the Circular Economy
Number	2537000020
ECTS	5,0
Compulsory requirements	

Compulsory attendance	
Expected performance/ Type of examination	1 Examination element: written exam (120 min)
Course achievement	

Objective qualification

After the completion of this module, the students should be able to master the theoretical basics for the usage of common engineering materials in the circular economy.
The hereby gained knowledge should enable students the assessment and application of production methods.
Furthermore, the students should be able to optimise production processes under consideration of technological and ecological aspects and put conventional processes in regard to more sustainable alternatives.

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Laboratory A

Title	Interdisciplinary Research Lab Battery
Number	2520000010
ECTS	6,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: term paper
Course achievement	1 Course Achievement: colloquium
Module grade composition	The three module parts are graded based on the oral test before laboratory and the respective section of the final report. Each section is graded by the individual institute. Each student is responsible for a certain section and he / she will prepare and write his / her respective section as the final report. For the part of InES, students must write this report and take the oral test in English. The final grade of every student is individually determined by his / her oral test and section report.
Objective qualification	
Students will learn the production chain for manufacturing batteries. By conducting experiments and simulation, students will gain knowledge of properties and processes in batteries. In the project, they will improve their ability of communication, teamwork and professional expression, besides laboratory working skills.	

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Title	Interdisciplinary Research Lab Hydrogen
Number	2521000100
ECTS	6,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	1 examination element: term paper
Course achievement	1 course achievement: colloquium
Objective qualification	
After completing this module, students will be able to professionally assemble, condition and operate fuel cells. They will understand the complex interrelationships in operation that result from the interaction of temperature, humidity, pressure and electrical power, and will be able to record and adjust the parameters spe-	

cifically with regard to the performance, efficiency and service life of the cell. Students will also be able to set up, validate and simulate simple fuel cell models based on the parameters mentioned.

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Integrated Courses

Title	Integrated Courses
Number	2599000080
ECTS	13,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	
Course achievement	a) English language course at C1 level (CEFR): Depending on the module chosen (4 ECTS) and b) German language course at B1 level (CEFR): Depending on the module chosen (4 ECTS) and c) Other elected courses, depending on the modules chosen (5 ECTS)
Objective qualification	
Language courses: Depending on elected courses Students will be able to categorise their subject in social, historical, legal or career-orientated contexts (depending on the focus of the course). They are able to recognise, analyse and evaluate overarching subject-related connections and their significance. Students gain an insight into the networking possibilities of the subject and the application of their subject in professional life.	

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Student Research Project

Title	Student Research Project
Number	2599870
ECTS	15,0
Compulsory requirements	
Compulsory attendance	
Expected performance/ Type of examination	2 examination element a) Written elaboration (to be weighted 13/15 in the calculation of module mark) b) oral examination in the form of a presentation (to be weighted 2/15 in the calculation of module mark)
Course achievement	
Objective qualification	
Students are able to, - familiarise themselves with a complex topic, - analyse the topic in order to define the necessary goals for successful processing and select appropriate work steps for this purpose - illustrate interdisciplinary approaches and concepts in order to be able to successfully master a given task - to transfer non-technical knowledge to a current task and to evaluate and apply it in the course of working on the task, both alone and in possible teams based on division of labour, in which the student research project can be written. - to formulate work results both in writing and orally and to present them critically in the context of an examination situation.	

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Master's Thesis

Title	Master's Thesis
Number	2599000070
ECTS	30,0
Compulsory requirements	Only students who • have passed the examinations in all modules of the core, profile, laboratory and elective area, • have successfully completed the course work, • have proven that they have passed all course work can be admitted to the Master's thesis.
Compulsory attendance	
Expected performance/ Type of examination	2 examination elements a) Written elaboration (to be weighted 9/10 in the calculation of module mark) b) oral examination in the form of a presentation(to be weighted 1/10 in the calculation of module mark)
Course achievement	

Objective qualification
Students are able to • independently investigate a complex, subject-specific problem, • analyse the subject matter in a scientifically sound manner and explore theses independently • define goal-oriented measures for successful processing and organise the optimal work steps for this purpose • independently design interdisciplinary approaches and define concepts in order to be able to successfully master a given task • combine non-technical knowledge with technical knowledge in the course of the work and to use it to carry out and document the work • present the results of the research in writing on the basis of independently researched relevant literature as well as orally and to discuss them critically within the framework of a presentation.

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