Overview

Module Handbook

for the Master´s Programme

Digitalization & Sustainability in Materials Science & Engineering

At the University of Bayreuth

Module XY: Module Name

Responsibility	Responsible department for the module			
Content	Description of the contents of the module.			
Qualification objective	Description of the qualification objective obtained through the module.			
Prerequisites	Modules or knowledge required for participation in the module			
Possible inclusion in curriculum	Specification of the semester from which the module can be taken.			
Language	English			
Subject area	Assignment of the module to a field of study.			
Frequency	Information on the frequency of the module. Annual: periodically either in the winter or summer semester.			
Duration	Number of semesters required for the module.			
Overview and credits	Identification	Course	SWS[1]	LP
	XY1	Course 1	nV[2] + nÜ[3] + nP[4]	LP[5]
	XY2	Course 2	nV + nÜ + nP	LP
		Total:	Total (nV+nÜ+nP)	Total LP
Examination	Type of module examination according to the study and examination regulations.			
Student workload	Workload calculated for the completion of a module. Usually divided into attendance time and self-study and exam preparation			
Assignment to Curriculum	Specification of the degree programs in which the module is used.			

[1] Semester hours per week
[2] Lecture
[3] Exercise lesson
[4] Practical course
[5] Credit Points

Table of Contents

Module BFM 5
Module BIM 6
Module BM 8
Module BMB 9
Module BMM 11
Module CMM 13
Module CKM 15
Module CLM 16
Module CMC 18
Module CRM 20
Module DSP 22
Module EM 23
Module ERT 25
Module FSET 26
Module HE 28
Module IE 30
Module IM 32
Module LF 34
Module MA 36
Module MI 37
Module MS 39
Module NAS 41
Module PIB 43
Module PM 45
Module PML 46
Module PoE 48
Module PS 50
Module RM1 52
Module RM2 53
Module SPD 54
Module SEC 56
Module SBI 57
Module SPM 59
Module TPI 59

Modules in alphabetical order

Module BFM: Biomaterials and Biofabrication MOOC

Responsibility	Chair of Biomaterials (Prof. Dr. Thomas Scheibel)			
Content	Key concepts in biomaterials and medical devices; clinical testing and quality assurance; key concepts and challenges in the field of tissue engineering; key concepts in biofabrication; how to develop products to solve biomedical problems; current trends in the field of biofabrication.			
Qualification objective	In-depth knowledge of the properties of biomaterials and medical devices; overview of concepts and challenges in biomedical engineering; overview of biofabrication concepts; acquisition of methodological skills for the development of new biomaterials and products for biomedical use; overview of current developments in the field of biofabrication.			
Prerequisites	Basics in biology, chemistry and physics equivalent to a university degree (Bachelor of Science)			
Language	English			
Possible inclusion in curriculum	In the second or third semester			
Subject area	Focus area: "Sustainable Applications & Processes for Materials"			
Frequency	Every semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	BFM	Biomaterials and Biofabrication MOOC	3V	5LP
		Total:	3V	5LP
Examination	Written exam			
Student workload	o 45 h Online course o 105 h Self-study and examination preparation BFM total: 150 h			
Assignment to Curriculum	DSMSE (M.Sc.), Biofabrication (M.Sc.)			

Module BIM: Biomimetics

Responsibility	Chair of Biomaterials (Dr. Hendrik Bargel), Chair of Biomechanics (Dr.-Ing. Michael Frisch)			
Content	Design principles of nature, selected examples of materials, structures, surface effects, resistance reduction, etc. as inspiration for biomimetic technical applications. Sustainable aspects in technical developments. Introduction to optimization algorithms, Self-X materials, energetic aspects; introduction to concepts of technical implementation and practical application based on selected examples.			
Qualification objective	Basic understanding of natural design principles, structures and concepts and their possible transfer to technical applications; acquisition of an introductory overview of the fields of bioinspired engineering; methodological competence in the selection of suitable materials, concepts and processes for the transfer of natural principles to biomimetic technical applications; acquisition of systematic decision-making competence with regard to possible technical applications.			
Prerequisites	General knowledge in the fields of engineering and materials science.			
Language	English			
Possible inclusion in curriculum	Second or third semester			
Subject area	Focus area: “Sustainable Applications & Processes for Materials”			
Frequency	BIM1: Periodically in the winter semester BIM2: Currently every semester, preference: summer semester			
Duration	2 semester			
Overview and credits	Identification	Course	SWS	LP
	BIM1	Biomimetics & Bio-inspired Materials 1	1V + 2P	3LP
	BIM2	Biomimetics & Bio-inspired Materials 2	1V	2LP
		Total:	2V+ 2P	5LP
Examination	Written exam (mark weighting 1/1), Contribution in the form of practical course reports (not graded)			
Student workload	BIM1: o 45 h Attendance time o 45 h Self-study and examination preparation			

	BIM1 total: 90 h BIM2: o 15 h Attendance time o 45 h Self-study and examination preparation BIM2 total: 60 h BIM total: 150 h
Assignment to Curriculum	Sporttechnologie (M.Sc.), DSMSE (M.Sc.)

Module BM: Battery Materials 1

Responsibility	Chair of Inorganic Active Materials for Electrochemical Energy Storage (Prof. Dr. Matteo Bianchini)			
Content	Introduction to energy storage technologies, battery definitions and concepts, fundamentals of solid-state chemistry and material chemical concepts in the field of electrode processes and reactions, phase diagrams, cathode, and anode materials (focus on electronic and crystal structure, synthesis, reactivity, and stability), introduction to common separators and electrolytes.			
Qualification objective	Interdisciplinary acquisition of competence in the field of battery materials. The students will learn about the synthesis, structure, and electrochemical properties of the most important electrode materials on the market, as well as those in the research stage. The course will focus on active materials.			
Prerequisites	None			
Language	English			
Possible inclusion in curriculum	Second or third semester			
Subject area	Focus area: "Sustainable Applications & Processes for Materials"			
Frequency	Every semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	BM	Battery Materials	3V + 1Ü	5LP
		Total:	3V+1Ü	5LP
Examination	Written or oral exam			
Student workload	o 60 h Attendance time o 90 h Self-study and examination preparation BM total: 150 h			
Assignment to Curriculum	DSMSE (M.Sc.), Battery Materials and Technology (M.Sc.)			

Module BMB: Biomaterials and Biocomponents

Responsibility	Chair of Biomaterials (Prof. Dr. Thomas Scheibel)			
Content	Materials science across material classes, biopolymers, composite materials, and hybrid materials; properties of biomaterials and biomineralization processes, biocompatibility, and material-cell interaction; testing methods; concepts for the development of new biomaterials; overview of the structure and function of macromolecules, design principles in nature; applications in nanotechnology, pharmacology/medical engineering, materials science, and industry.			
Qualification objective	Acquisition of knowledge about material science across material classes, natural macromolecules, and biopolymers; acquisition of a comprehensive overview of the properties of biomaterials and their processing; material-cell interactions; acquisition of method competence for the analysis of biomaterials and bio-components; acquisition of decision-making competence with regard to possible technical applications.			
Prerequisites	Knowledge to the extent of a university bachelor's degree program, especially in the fields of biology, chemistry and physics.			
Language	English			
Possible inclusion in curriculum	First or second semester			
Subject area	Compulsory elective area: “Materials Science”			
Frequency	Periodically in the summer semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	BMB1	Biomaterials	2V	3LP
	BMB2	Biocomponents & Natural Composite Materials	1V	2LP
		Total:	3V	5LP
Examination	Written exam			
Student workload	BMB1: o 30 h Attendance time o 60 h Self-study and examination preparation BMB1 total: 90 h BMB2:			

	○ 15 h Attendance time o 45 h Self-study and examination preparation BMB2 total: 60 h BMB total: 150 h
Assignment to Curriculum	DSMSE (M.Sc.), Biotechnologie und chemische Verfahrenstechnik (M. Sc.)

Module BMM: Basics of Metallic Materials

Responsibility	Chair of Metals and Alloys (Jun. Prof. Dr.-Ing. Anke Silvia Ulrich)			
Content	Introduction to melting, re-melting and casting processes and theoretical aspects of heat treatments; overview and selection criteria for metallic materials in the chemical industry and power engineering. Extension of knowledge in alloy composition and its effect on mechanical properties and oxidation and corrosion behavior. Failure analysis (theory and practice).			
Qualification objective	Understanding of phases and states of metallic materials in the molten and solidified state as well as processes at their interfaces; modeling approaches for the simulation of these processes; mastering the basics of failure analysis in the chemical industry and power engineering, determining criteria for material selection, overview of possible causes of damage and their prevention, understanding between material selection and material requirements.			
Prerequisites	General knowledge in the fields of engineering and materials science.			
Language	English			
Possible inclusion in curriculum	First or second semester			
Subject area	Compulsory elective area: “Materials Science”			
Frequency	Periodically in the winter semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	BMM1	Metals and Alloys: Liquid, Solid, Interfaces	1V	2LP
	BMM2	Metals and Alloys: Material Selection	1V + 1P	3LP
		Total:	2V + 1P	5LP
Examination	Portfolio examination: Oral examination (mark weighting 1/1). Contribution in the form of practical course reports (not graded).			
Student workload	BMM1: o 15 h Attendance time o 45 h Self-study and examination preparation BMM1 total: 60 h BMM2:			

	o 30 h Attendance time o 60 h Self-study and examination preparation BMM2 total: 90 h BMM total: 150 h
Assignment to Curriculum	DSMSE (M.Sc.)

Module CMM: Computational Materials Modeling

Responsibility	Chair of Biomaterials (Dr. Thomas Gruhn)			
Content	The module provides an introduction to materials simulation methods. Concepts and the application of materials simulations are explained and practiced in detail. As shown in the course, materials simulations provide an important contribution to the development of sustainable functional materials; the selection and optimization of materials on the computer significantly reduces the amount of rare and expensive substances and the experimental effort required in materials development. The module introduces molecular dynamics (MD) and Monte Carlo (MC) simulations, ab initio methods, and field simulations. Links to AI methods are explained. Students explore the simulation methods in small projects on the computer. The simulation methods are demonstrated for example using the following environmentally relevant materials: - thin-film solar cell materials - thermoelectric materials - sustainable composite materials			
Qualification objective	- Competence in modern methods of multiscale materials simulations - Proficiency in the application of MD, and MC, and field simulations - Ability to develop own simulation programs for the preparation and analysis of simulations (post-processing)			
Prerequisites	Basic knowledge of Python, for example from the course PML1 (Compulsory Area Informatics).			
Language	English			
Possible inclusion in curriculum	Second or third semester.			
Subject area	Focus Area: “Digitalization in Materials Sciences”			
Frequency	Periodically in the summer semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	CMM	Computational Materials Modeling	2V + 2Ü	5 LP
		Total:	2V + 2Ü	5 LP
Examination	Written or oral examination (K or MP)			
Student workload	○ 60 h Attendance time ○ 90 h Self-study and examination preparation CMM total: 150 hours			

Assignment to Curriculum	DSMSE (M.Sc.)

Module CKM: Connected Knowledge in Materials Science

Responsibility	Study programme moderator			
Content	Relationships between physical and chemical mechanisms in different classes of materials; kinetic and thermodynamic principles.			
Qualification objective	In-depth understanding of fundamental interrelationships, ability to think in a networked way in the field of materials science and materials engineering. Assessment skills with regard to materials and their material characteristics as well as materials engineering processes.			
Prerequisites	General knowledge in the fields of engineering and materials science.			
Language	English			
Possible inclusion in curriculum	First semester			
Subject area	Compulsory area: „Connected Knowledge in Materials Science“			
Frequency	Every semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	CKM	Connected Knowledge in Materials Science	4V	7LP
		Total:	4V	7LP
Examination	Written exam			
Student workload	o 60 h Attendance time o 150 h Self-study and examination preparation CKM total: 210 h			
Assignment to Curriculum	DSMSE (M.Sc.)			

Module CLM: Carbon & Life Cycle Management

Responsibility	Chair of Polymer Engineering (Prof. Dr.-Ing Holger Ruckdäschel) (with chair of Ecological Resource Technology (Prof. Dr.-Ing. Christoph Helbig))			
Content	Carbon Management (CLM1): Background and initial situation, e.g. global warming, based on global natural and anthropogenic factors. Carbon balance. Options for managing carbon-based flows such as avoidance, reduction, modified feedstocks, and offsetting. Calculation and accounting fundamentals for product-related carbon footprints with examples from industrial practice in plastics. Cost implications and industrial feasibility. Life Cycle Management (CLM2): Planetary boundaries and planetary crises in addition to climate change as the baseline. Evaluation using the Life Cycle Assessment (LCA) method with the phases Goal & Scope, Life Cycle Inventory, Life Cycle Impact Assessment, Interpretation & Analysis. Consideration of the product life stages of raw material extraction, production, use and end of life, including recycling flows. Mathematical structure of LCA. Introduction to the use of LCA software and databases.			
Qualification objective	Knowledge for a holistic view of carbon management and the use of renewable energies. Linking industrial practice with scientific fundamentals. Based on national and international standards and regulations for Life Cycle Assessment and Life Cycle Management, students should be able to determine and evaluate LCA indicators and identify suitable improvement measures.			
Prerequisites	Advanced study skills acquired in a bachelor's degree program in natural sciences or engineering			
Language	English			
Possible inclusion in curriculum	First or second semester			
Subject area	Compulsory area: “Sustainability”			
Frequency	Periodically in the winter semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	CLM1	Carbon Management	2V	3LP
	CLM2	Life Cycle Management	1V + 1Ü	2LP
		Total:	2V + 1Ü	5LP

Examination	Written exam
Student workload	CLM1: o 30 h Attendance time o 60 h Self-study and examination preparation CLM1 total: 90 h CLM2: o 30 h Attendance time o 30 h Self-study and examination preparation CLM2 total: 60 h CLM total: 150 h
Assignment to Curriculum	DSMSE (M.Sc.)

Module CMC: Ceramic Matrix Composites

Responsibility	Chair of Ceramic Materials Engineering (Prof. Dr.-Ing. Stefan Schafföner)			
Content	Current research aspects of ceramic fiber composite materials, their fabrication, structure, properties, characterization methods and applications; design of ceramic composite structures; overview of technical fibers, structure, fabrication, properties and applications.			
Qualification objective	Specific knowledge of the properties of ceramic composites and reinforcing components; decision-making competence for application-specific selection and failure mechanisms of ceramic composites; ability to assess the application potential of reinforcing fibers.			
Prerequisites	General knowledge in the fields of engineering and materials science.			
Language	English			
Possible inclusion in curriculum	First or second semester			
Subject area	Compulsory elective area: "Materials Science"			
Frequency	Periodically, in the winter semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	CMC1	Ceramic Matrix Composites	2V	3LP
	CMC2	Technical Fibers	1V + 1P	2LP
	Total:		3V + 1P	5LP
Examination	Oral exam			
Student workload	CMC1: o 30 h Attendance time o 60 h Self-study and examination preparation CMC1 total: 90 h CMC2: o 30 h Attendance time o 30 h Self-study and examination preparation CMC2 total: 60 h CMC total: 150 h			

Assignment to Curriculum	DSMSE (M.Sc.)

Module CRM: Critical Raw Materials

Responsibility	Chair of Ecological Resource Technology (Prof. Dr.-Ing. Christoph Helbig)			
Content	Critical Raw Materials (CRM1): Recent findings in the research field of resource criticality research. Case study based assessments of geological, technical, economic, environmental and social aspects of criticality. The case studies consider the assessment of supply security and resilience of established and emerging technologies, including batteries. The applied methods include the assessment of raw material criticality, the methodologies underlying the indicators, as well as methods of risk management and decision theory. Critical Raw Materials (CRM2): Focus on modeling and evaluation of selected issues in the area of resource criticality assessment, corresponding to the content of the lecture, in small groups of 1-3 students depending on the issue.			
Qualification objective	Knowledge of evaluation methods for critical raw materials from a technological, entrepreneurial, and economic point of view. Evaluation indicators for supply risks and economic importance of materials and technologies. Collection and preparation of data for own criticality assessments. Recommendations for the handling of critical raw materials from the fields of technology, circular economy, and politics.			
Prerequisites	Advanced study skills acquired in a bachelor's degree program in natural sciences or engineering			
Language	English			
Possible inclusion in curriculum	First or second semester			
Subject area	Focus area: “Circular Economy & Sustainable Raw Materials”			
Frequency	Periodically in the summer semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	CRM1	Critical Raw Materials	2V	2LP
	CRM2	Seminar Critical Raw Materials	2S	3LP
		Total:	2V + 2S	5LP
Examination	Portfolio examination: CRM1: Oral exam (mark weighting 2/5); CRM2: Presentation (mark weighting 1/5) and contribution or written elaboration in the form of a seminar paper (mark weighting 2/5).			
Student workload	CRM1:			

	o 30 h Attendance time o 30 h Self-study and examination preparation CRM1 total: 60 h CRM2: o 30 h Attendance time o 60 h Selbststudium CRM2 total: 90 h CRM total: 150 h
Assignment to Curriculum	DSMSE (M.Sc.), Materialwissenschaften und Werkstofftechnik (M.Sc.)

Module DSP: Data Science for Polymers

Responsibility	Chair of Polymer Engineering (Prof. Dr.-Ing. Holger Ruckdäschel)			
Content	Students gain an insight into acquisition, analysis, and machine learning methods in the field of polymeric materials. The focus is on the formulation and processing of these. The topics of connectivity, Internet of Things (IoT), inline measurement methods and databases are covered. In addition, students are given an overview of methods of digitized material development and analysis. In addition, practical experiments are carried out on digitally supported material development and analysis with a focus on plastics processing.			
Qualification objective	Students develop an understanding of data acquisition and utilization systems in the field of plastics technology. They are able to apply methods to carry out selected material analyses and developments with digital support. In addition, they are familiar with inline measurement methods and understand the relevance of data utilization in processing.			
Prerequisites	Knowledge on polymer technology, for example obtained from other polymer modules within the programme.			
Language	English			
Possible inclusion in curriculum	Second or third semester			
Subject area	Focus area: „Digitalization in Materials Science“			
Frequency	Periodically in the summer semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	DPI	Data Science for Polymers	1V + 1Ü + 3P	5LP
		Total:	1V + 1Ü + 3P	5LP
Examination	Portfolio examination: Written exam (mark weighting 1/1), Contribution in the form of practical course reports (not graded).			
Student workload	o 75 h Attendance time o 75 h Self-study and examination preparation DSP total: 150 h			
Assignment to Curriculum	DSMSE (M.Sc.)			

Module EM: Energy Materials

Responsibility	Chair of Electrochemical Process Engineering (Prof. Dr. Christina Roth)			
Content	Modern methods of solid-state analysis for the characterization of (functional) materials and layers with respect to structure and chemical composition, connection with current research in materials science, X-ray diffraction (XRD), Small-angle X-ray scattering (SAXS), but also X-ray photoelectron spectroscopy (XPS) and X-ray absorption spectroscopy (XAS). Principle and instrumental design of the different measurement techniques (sources, monochromators, detectors). Review of electrochemical fundamentals for the design of electrochemical processes; electrocatalytic principles for the development of new materials systems; introduction to common electrochemical measurement techniques; focus on applications in electrochemical energy technology, such as fuel cells, redox flow batteries, and electrochemical CO2 reduction.			
Qualification objective	In-depth understanding of solid-state characterization methods using various probes (x-ray, ion, electron) and related terminology. Ability to select the most appropriate method for a given problem. Competence in the selection of appropriate electrocatalysts and the development of new electrochemical concepts; knowledge of various degradation phenomena and the ability to propose appropriate methods for their analysis and prevention.			
Prerequisites	General knowledge in the fields of engineering and materials science. Knowledge of German is a prerequisite.			
Language	German			
Possible inclusion in curriculum	Second or third semester			
Subject area	Focus area: “Sustainable Applications & Processes for Materials”			
Frequency	Yearly			
Duration	2 semester			
Overview and credits	Identification	Course	SWS	LP
	EM1	Methoden der Festkörpercharakterisierung	2V	2LP
	EM2	Elektrochemische Verfahrenstechnik	2V + 1S	3LP
		Total:	2V + 1S	5LP
Examination	Portfolio examination: EM1: written exam (mark weighting 2/5) EM2: oral or written exam (mark weighting 3/5)			

Student workload	EM1: o 30 h Attendance time o 30 h Self-study and examination preparation EM1 total: 60 h EM2: o 30 h Attendance time o 60 h Self-study and examination preparation EM2 total: 90 h EM total: 150 h
Assignment to Curriculum	DSMSE (M.Sc.)

Module ERT: Environmental and Resource Technology

Responsibility	Chair of Ecological Resource Technology (Prof. Dr.-Ing. Christoph Helbig) (with chair of Chemical Engineering, (Prof. Dr.-Ing. Andreas Jess))			
Content	• Bio geosphere • Energy balance of the earth • Anthropogenic material and energy flows and limitations • Energy demand and stable ecosystems • Sustainability product engineering • Water demand and resources • Production and recycling of waste • Agricultural technology			
Qualification objective	The module focuses on the earth planet and its atmosphere, on greenhouse and warming effects as well as on anthropogenic material and energy flows and their limitations. Energy and water demand, stable ecosystems and production and recycling of waste will be discussed.			
Prerequisites	Advanced study skills acquired in a Bachelor's degree program in natural sciences or engineering			
Language	English			
Possible inclusion in curriculum	First or second semester			
Subject area	Compulsory area: "Sustainability"			
Frequency	Periodically, in the winter semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	ERT	Environmental & Resource Technology	4V	5LP
		Total:	4V	5LP
Examination	Written or oral exam or presentation or written elaboration or contribution			
Student workload	o 60 h Attendance time o 90 h Self-study and examination preparation ERT total: 150 h			
Assignment to Curriculum	DSMSE (M.Sc.), Environment, Climate Change and Health (M.Sc.)			

Module FSET: Functional Materials and Systems Aspects for Energy and Environmental Technology

Responsibility	Chair of Functional Materials (Prof. Dr.-Ing. Ralf Moos)			
Content	Materials and their functional properties with respect to energy and environmental applications: Solid electrolyte ionic conductors, solid electrolyte fuel cells and electrolyzers, electrical characterization of materials (e.g. impedance spectroscopy), fundamentals of batteries, lithium battery materials, materials for exhaust aftertreatment (e.g. SCR catalysts, silicon (fundamentals, technology, applications, e.g. solar cells), thermoelectrics (fundamentals, materials, applications)).			
Qualification objective	Understanding of functional material properties, with particular emphasis on the use and processing of such materials in energy and environmental engineering applications, and methods for their characterization. Assessment competence and ability to (further) develop energy and environmental engineering applications.			
Prerequisites	Advanced study skills. Basic knowledge in the field of engineering.			
Language	English			
Possible inclusion in curriculum	First or second semester			
Subject area	Compulsory elective area: “Materials Science”			
Frequency	Periodically, in the summer semester			
Duration	1 semester.			
Overview and credits	Identification	Course	SWS	LP
	FSET1	Functional Materials and Systems Aspects for Energy and Environmental Technology	3V	4LP
	FSET2	Functional Materials and Systems Aspects for Energy and Environmental Technology	1P	1LP
		Total:	3V + 1P	5LP
Examination	Portfolio examination: Written or oral exam (Mark weighting 1/1), Contribution in the form of practical course reports (not graded).			
Student workload	FSET1: o 45 h Attendance time o 75 h Self-study and examination preparation			

	FSET1 total: 120 h FSET2: o 10 h Attendance time o 20 h Self-study and examination preparation FSET2 total: 30 h FSET total: 150 h
Assignment to Curriculum	DSMSE (M.Sc.)

Module HE: Hydrogen embrittlement: phenomenon and mechanism

Responsibility	Chair of Metals and Alloys (Prof. Dr.-Ing. Anke Silvia Ulrich)			
Content	Types of hydrogen embrittlement, hydrogen-induced cracking, fundamental mechanisms and theories of hydrogen influence, hydrogen embrittlement features in metallic materials, practical examples of hydrogen influence on metallic structural elements in piping systems, in automotive, air and rail transportation.			
Qualification objective	Understanding the hydrogen embrittlement phenomenon, as well as knowledge of hydrogen effect on metallic materials and their mechanical properties.			
Prerequisites	General knowledge in the fields of engineering and materials science.			
Language	English			
Possible inclusion in curriculum	Second or third semester			
Subject area	Focus area: "Sustainable Applications & Processes for Materials"			
Frequency	Periodically in the winter semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	HE1	Hydrogen Embrittlement: Phenomenon and Mechanism	2V + 1P	4LP
	HE2	Seminar: Hydrogen Embrittlement: Phenomenon and Mechanism	1S	1LP
		Total:	2V + 1P + 1S	5LP
Examination	Portfolio examination: HE1: oral exam (Mark weighting: 4/5) Contribution in the form of practical course reports (not graded) HE2: Presentation in the form of a seminar talk (Mark weighting 1/5)			
Student workload	HE1: o 45 h Attendance time o 75 h Self-study and examination preparation HE1 total: 120 h HE2: o 15 h Attendance time			

	o 15 h Self-study HE2 total: 30 h HE total: 150 h
Assignment to Curriculum	DSMSE (M.Sc.), Materialwissenschaften und Werkstofftechnik (M.Sc.)

Module IE: Impact Entrepreneurship – Developing Social and Ecological Innovations

Responsibility	BWL XX: Entrepreneurial Behavior (Prof. Dr. Rebecca Preller) JP Social Entrepreneurship (Prof. Dr. Eva Jakob)			
Content	Students learn advanced knowledge in the field of impact entrepreneurship (i.e., solving social and/or ecological problems through innovative methods). Furthermore, they learn to develop sustainable solutions for social and/or ecological challenges. In addition to obtaining a foundation of scientifically based content on impact entrepreneurship, students learn the necessary tools and their application in practice-oriented workshop and will also be personally advised in a team by the interdisciplinary lecturers.			
Qualification objective	The aim is to connect interdisciplinary master's students from all faculties and to enable them to jointly develop solutions for social and/or ecological problems using innovative methods. Examples of these are acute and global challenges such as biodiversity loss, climate change, environmentally friendly production/additive manufacturing, nutrition and smart cities. By taking the course, sustainable, impact-oriented action can be experienced and solutions to global problems are developed. Through this course, students will not only learn a range of methods to address global challenges, but also develop a deeper understanding of these challenges, which is especially enhanced through interdisciplinary collaboration.			
Prerequisites	None.			
Language	English			
Possible inclusion in curriculum	First or second semester			
Subject area	Compulsory elective area: „Social, Economic and Legal Aspects"			
Frequency	Currently offered each semester. The module could be offered in blocks. The dates will be announced in a separate notice.			
Duration	1 semester (Vorlesung 2 SWS, Übung 2 SWS).			
Overview and credits	Identification	Course	SWS	LP
	IE	Impact Entrepreneurship – Developing Social and Ecological Innovations	2V + 2Ü	6LP
		Total:	2V + 2Ü	6LP
Examination	Presentation (mark weighting 1/2). Term paper of a solution concept (mark weighting 1/2)			
Student workload	o 40 h Attendance time o 140 h Self-study and examination preparation IE total: 180 h			

Assignment to Curriculum	Business Administration (M.Sc.); Entrepreneurship & Digitalization (M.Sc.), DSMSE (M.Sc.)

Module IM: Innovation Management

Responsibility	Chair of Biomaterials (Prof. Dr. Thomas Scheibel)			
Content	Exploring the innovation management process and product development process models. Hands-on case studies to understand key concepts. Conception and creation of a trend report and product proposal.			
Qualification objective	Knowledge of product development processes and models, fundamentals of tools and methods for product development up to product launch, mastery of essential soft skills (teamwork, time management, self- and team-evaluation), fundamentals of independent project planning; training of the ability to present and discuss scientific contexts.			
Prerequisites	Advanced study ability			
Language	English			
Possible inclusion in curriculum	In the first or second semester			
Subject area	Compulsory elective area: „Social, Economic and Legal Aspects"			
Frequency	Yearly, periodically in the summer and winter semester			
Duration	2 semester			
Overview and credits	Identification	Course	SWS	LP
	IM1	Innovation Management 1	2V	3LP
	IM2	Innovation Management 2	2V	3LP
		Total:	4V	6LP
Examination	Portfolio examination: Contribution to seminar (3/5), written elaboration (2/5)			
Student workload	IM1: o 30 h Attendance time o 60 h Self-study and examination preparation IM1 total: 90 h IM2: o 30 h Attendance time o 60 h Self-study and examination preparation IM2 total: 90 h IM total: 180 h			

Assignment to Curriculum	DSMSE (M.Sc.), Biofabrication (M.Sc.), Biotechnology and Process Engineering (M.Sc.)

Module LF: Laboratory to Fabrication

Responsibility	Chair of Electrochemical Process Engineering (Prof. Dr.-Ing. Christina Roth)			
Content	Overview of energy conversion devices (for hydrogen production and utilization), materials used for electrocatalysis, electrode manufacturing processes and realistic operational conditions. Upscaling of electrodes for energy conversion Rheological behaviors of material dispersions under shear stress: Newtonian and non-Newtonian fluids, aggregate size and zeta potential. Surface tension and surface energy of substrates and coating technologies for serial production- precision printing, slot die coating, gravure coating, etc.). Basics of slot die coating, parameters controlling homogeneity of coatings. Curing methods (convection, IR, and quality controls (thickness measurements, homogeneity and distribution, control of cracking behavior) of catalyst layer films Latest developments in mitigation strategies for reduction of critical raw materials: from material design, intelligent processing, recycling and reintegration of components.			
Qualification objective	In-depth understanding of how material and electrode preparation processes can be scaled up for serial fabrication. Introduce concepts of targeted/metered design of processes and inspire critical thinking to understand inter-dependence of material science and process engineering to bring lab scale ideas to commercialization of clean and sustainable energy sources.			
Prerequisites	General knowledge in the fields of engineering and materials science.			
Language	English			
Possible inclusion in curriculum	Second or third semester			
Subject area	Focus area: "Sustainable Applications & Processes for Materials"			
Frequency	Periodically in the winter semester			
Duration	1 semester			
Overview and credits	Identification	Veranstaltung	SWS	LP
	LF1	Laboratory to Fabrication	2V	3LP
	LF2	Practical course Laboratory to Fabrication	2P	2LP
		Summe:	Gesamt (2V+2P)	5LP

Examination	Written or oral exam (100%) and contribution (not graded).
Student workload	Lecture: 30 h Attendance time 60 h Self-study and examination preparation Practical: 30 h Attendance time 30 h Self-study and report Total: 150 h
Assignment to Curriculum	DSMSE (M.Sc.)

Module MA: Master Thesis

Responsibility	Chairs of the Faculty of Engineering Science			
Content	Written report on a current topic in the field of engineering provided or co-supervised by a professor or associate professor of the Faculty of Engineering Science.			
Qualification objective	Ability to work independently on a research-relevant engineering problem; practice in written and oral presentation and communication techniques.			
Prerequisites	Advanced study ability			
Language	English			
Possible inclusion in curriculum	Fourth semester			
Subject area	Master Thesis			
Frequency	Every semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	MA	Master Thesis	-	30LP
		Total:	-	30LP
Examination	Master Thesis (mark weighting 3/4) and presentation (mark weighting 1/4)			
Student workload	Modul MA total: 900 h			
Assignment to Curriculum	DSMSE (M.Sc.)			

Module MI: Materials Informatics

Responsibility	Computational Materials Science (Prof. Dr. Christopher Künneth)			
Content	Introduction and advanced concepts of machine learning; application in materials science			
Qualification objective	Students will understand the fundamentals and advanced concepts of machine learning and be able to build machine learning models for materials.			
Prerequisites	Successful completion of the compulsory module area "Informatics"			
Language	English			
Possible inclusion in curriculum	Second or third semester			
Subject area	Focus area: “Digitalization in Materials Science“			
Frequency	MI1: Every semester MI2: Periodically in the winter semester			
Duration	2 semester			
Overview and credits	Identification	Course	SWS	LP
	MI1	Machine Learning in Materials Science	2V + 2Ü	3LP
	MI2	Emerging Trends in Materials Informatics	1S	2LP
		Total:	2V+2Ü+1S	5LP
Examination	Portfolio examination: MI1: written or oral examination (mark weighting 3/5) and written elaboration or semester tasks (not graded). MI2: written examination or semester tasks (mark weighting 2/5)			
Student workload	MI1: o 60 h Attendance time o 30 h Self-study and examination preparation MI1 total: 90 h MI2: o 15 h Attendance time o 45 h Self-study and examination preparation MI2 total: 60 h MI total: 150 h			

Assignment to Curriculum	DSMSE (M.Sc.)

Module MS: Materials Selection across Materials Classes

Responsibility	Chair of Electrochemical Process Engineering (Dr.-Ing. Daniel Leykam)			
Content	Materials selection methods are taught as an integral part of the design process, taking into account all the material properties required for manufacture and the properties of a product. In addition to technical and economic aspects, the course also focuses on sustainability and energy efficiency. Concrete examples will be used to practice the application of the methods learned and to prepare and present a seminar paper. Current developments will be taken into account.			
Qualification objective	Knowledge of methods for identification and evaluation of manufacturing and design-related properties of parts and products. Ability to develop requirement profiles based on general criteria and justify the selection of materials.			
Prerequisites	Advanced study ability; Knowledge to the extent of a university bachelor's degree program, especially in the fields of materials science and process engineering.			
Language	English			
Possible inclusion in curriculum	Second or third semester			
Subject area	Focus area: "Circular Economy & Sustainable Raw Materials"			
Frequency	Periodically in the winter semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	MS1	Materials selection across materials classes	2V	3LP
	MS2	Materials Selection and Sustainable Development	1S	2LP
		Total:	2V + 1S	5LP
Examination	Portfolio examination: Oral examination (mark weighting 2/3) and presentation in the form of a seminar talk (mark weighting1/3)			
Student workload	MS1: ○ 30 h Attendance time o 60 h Self-study and examination preparation			

	MS1 total: 90 h MS2: o 15 h Attendance time o 45 h Self-study and examination preparation MS2 total: 60 h MS total: 150 h
Assignment to Curriculum	DSMSE (M.Sc.)

Module NAS: Numerical Methods and Applied Statistics

Responsibility	Chair of Electrode Design of Electrochemical Energy Systems (Prof. Dr. Francesco Ciucci)
Content	NAS1: Introduction to ordinary and partial differential equations, numerical methods for solving differential equations, error analysis, interpolation, and approximation. NAS2: Introduction to probability; random variables and stochastic processes; nonlinear regression and statistics; modeling stochastic processes.
Qualification objective	At the end of the module, students will be able to apply basic concepts of probability and statistics to support experiments and analyses in materials science. They will also be able to explain the concepts underlying random processes. Furthermore, the students will be able to describe materials using differential equations and solve them using numerical methods.
Prerequisites	None
Language	English
Possible inclusion in curriculum	First or second semester
Subject area	Compulsory area: „Informatics“
Frequency	NAS1: Every summer semester NAS2: Every winter semester
Duration	2 semester

Overview and credits

Identification	Course	SWS	LP
NAS1	Numerical methods	2V	2LP
NAS2	Applied Statistics	1V+ 1Ü	3 LP
	Total:	3V+1Ü	5LP

Examination	Portfolio examination: NAS1: Written exam (Mark weighting 2/5) NAS2: Written exam (Mark weighting 3/5).
Student workload	NAS1: o 30 h Attendance time o 30 h Self-study and examination preparation NAS1 total: 60 h NAS2:

	o 30 h Attendance time o 60 h Self-study and examination preparation NAS2 total: 90 h NAS total: 150 h
Assignment to Curriculum	DSMSE (M.Sc.)

Module PIB: Polymer Interfaces and Biosensors

Responsibility	Functional Polymer Interfaces Research Group (Prof. Dr. Alla Synytska)			
Content	Advanced knowledge in the scalable structuring and functionalization of surfaces, their characterization and processing for the design of target materials. Interfaces and surface modifications have a major impact on the interactions between matter and the environment. Modern functional materials are often produced by combining several (bio)polymers or by loading (bio)polymers with inorganic materials. To ensure the functionality of these hybrids, the design of the internal interfaces as well as the control of their morphology is of crucial importance. Due to their high surface-to-volume ratio, particulate systems are inherently characterized by interfaces, and polymer-based particulate systems are promising carrier materials for biological markers and the formulation of inks for bioanalytical devices and biosensors. This module consists of (i) Introduction to chemical modification of planar and special surfaces and interfaces; (ii) Overview of analytical methods used for structural and functional characterization of surfaces and interfaces at different levels; (iii) Ink formulation and advanced fabrication methods for printing; (iv) Functional biological interfaces and biosensors.			
Qualification objective	Extensive knowledge of design, material processing and characterization techniques for the targeted production of (bio)polymer-based materials for biosensors.			
Prerequisites	Advanced study ability			
Language	English			
Possible inclusion in curriculum	Second or third semester			
Subject area	Focus area: "Sustainable Applications & Processes for Materials"			
Frequency	Periodically in the winter semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	PIB1	Polymer Interfaces & Biosensors	2V	3LP
	PIB2	Practical course in Polymer Interfaces & Biosensors	2P	2LP

	Total:	2V + 2P	5LP
Examination	Written exam		
Student workload	PIB1: o 30 h Attendance time o 60 h Self-study and examination preparation PIB1 total: 90 h PIB2: o 30 h Attendance time o 30 h Selbststudium PIB2 total: 60 h PIB instotal: 150 h		
Assignment to Curriculum	Biofabrication (M.Sc.), DSMSE (M.Sc.)		

Module PM: Polymer Materials and Technology (DSMSE)

Responsibility	Chair of Macromolecular Chemistry I (Prof. Dr. Johannes Brendel) (with Chair of Polymer Engineering (Prof. Dr.-Ing. Holger Ruckdäschel))			
Content	The lecture provides detailed knowledge of the basic polymer processing techniques, such as injection molding, extrusion, secondary shaping techniques, as well as general applications. In addition, basic thermal and mechanical characterization methods are reviewed. A special emphasis will be given on the relationship between processing parameters and resulting product properties. In the laboratory course the knowledge on the different processing and characterization techniques is enhanced by experiments using state-of-the-art machines and equipment. Thus, processes such as injection molding and film extrusion are performed and thermal, optical, and mechanical properties will be evaluated on the produced components.			
Qualification objective	This module will provide systematic knowledge about conventional and advanced processing technologies of polymer materials. The objective is to understand the entire process chain starting from the selection of the polymer material, the involved processing to the final component in view of the desired properties.			
Prerequisites	Fundamentals in the field of natural sciences and engineering			
Language	English			
Possible inclusion in curriculum	First or second semester			
Subject area	Compulsory elective area: “Materials Science”			
Frequency	Periodically in the winter semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	PM	Polymer Materials and Technology	2V + 2 P	5 LP
Examination	Portfolio examination: Oral exam (mark weighting 1/1), Contribution in the form of practical course reports (not graded).			
Student workload	o 60 h Attendance time o 90 h Self-study and examination preparation PM total: 150 h			
Assignment to Curriculum	DSMSE (M.Sc.)			

Module PML: Python and Machine Learning for Non-Programmers

Responsibility	Chair of Polymer Engineering (Dr. Rodrigo Albuquerque)			
Content	Python: Introduction to the Python programming language; data and development tools; small programming projects. ML: Introduction to machine learning; machine learning concepts and small applications			
Qualification objective	By the end of this module, students will be able to use Python to read, extract, process, organize, and store data. Students will also master the basics of machine learning and be able to build simple machine learning models.			
Prerequisites	None			
Language	English			
Possible inclusion in curriculum	First or second semester			
Subject area	Compulsory area: "Informatics"			
Frequency	Every semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	PML1	Python and data tools for Non-Programmers	1V + 3Ü	3LP
	PML2	Machine Learning for Beginners: Theory + Applications	1V	2LP
		Total:	2V + 3Ü	5LP
Examination	Portfolio examination: PML1: written elaboration (Mark weighting 3/5). PML2: semester tasks or written elaboration (Mark weighting 2/5).			
Student workload	PML1: o 60 h Attendance time o 30 h Self-study and examination preparation PML1 total: 90 h PML2: o 15 h Attendance time			

	o 45 h Self-study and examination preparation PML2 total: 60 h PML instotal: 150 h
Assignment to Curriculum	DSMSE (M.Sc.)

Module PoE: Principles of Entrepreneurship

Responsibility	BWL XVI: Chair of Entrepreneurship und Digital Business Models (Prof. Dr. Matthias Baum)			
Content	In the lecture, students learn the basic principles of entrepreneurship, get acquainted with entrepreneurial processes, learn how to conduct feasibility analyses, how to design economically sustainable business models and how corporate entrepreneurship helps established organizations to stay innovative. In the exercises part, students have to apply their knowledge and solve small case studies.			
Qualification objective	Students learn about entrepreneurial processes and entrepreneurial decision-making as well as how to create innovative ideas and how to move from such ideas to an entrepreneurial firm. Moreover, students become acquainted with the basic principles of analyzing business opportunities, designing feasible business models and what it takes to develop innovative startup companies. Students further develop competencies in performing industry and competitor analyses, designing customer oriented value propositions and get to know the basics of corporate entrepreneurship.			
Prerequisites	Previous registration is necessary. Please note the separate notices and announcements.			
Language	English			
Possible inclusion in curriculum	First or second semester			
Subject area	Compulsory elective area: „Social, Economic and Legal Aspects"			
Frequency	Currently every semester; The module might be offered as in blocks. The dates will be announced in a separate notice.			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	PoE	Principles of Entrepreneurship	2V+2Ü	6LP
		Total:	2V + 2Ü	6LP
Examination	Presentation (Mark weighting 1/2), written elaboration (Mark weighting 1/2).			
Student workload	o 60 h Attendance time o 120 h Self-study and examination preparation PoE total: 180 h			
Assignment to Curriculum	Business Administration (M.Sc.), DSMSE (M.Sc.)			

Module PS: Polymer Systems for Sustainable Applications

Responsibility	Chair of Polymer Engineering (Prof. Dr.-Ing. Holger Ruckdäschel)			
Content	PS1: Structure, properties and methods of preparation of cellular thermoplastic polymer materials. Applications of cellular polymers with respect to their mechanical, insulating, and lightweight properties. PS2: Focus on the use of wind energy for sustainable power generation. History and physical principles of wind energy. Aerodynamics of wind turbines and derived design principles. Rotor blade design and manufacturing processes. Materials used in rotor blades (composites, adhesives, coatings). Wind turbine testing and certification. Installation, operation, and economics of wind turbines, including comparison with other forms of energy generation.			
Qualification objective	In-depth knowledge of the property profile of thermoset and cellular, thermoplastic polymer materials depending on the manufacturing process; understanding of the possible uses of polymer materials for innovative and sustainable applications; materials engineering, technological and socio-economic fundamentals of wind energy.			
Prerequisites	General knowledge in the field of materials science.			
Language	English			
Possible inclusion in curriculum	Second or third semester			
Subject area	Focus area: "Sustainable Applications & Processes for Materials"			
Frequency	PS1: Every semester PS2: Periodically in the summer semester			
Duration	1 -2 semester			
Overview and credits	Identification	Course	SWS	LP
	PS1	MOOC „Cellular Polymers"	3V	3LP
	PS2	Renewable Energies	1V + 1Ü	2LP
		Total:	4V + 1Ü	5LP
Examination	Written examination			
Student workload	PS1: o 45 h Online course			

	o 45 h Self-study and examination preparation PS1 total: 90 h PS2: o 30 h Attendance time o 30 h Self-study and examination preparation PS2 total: 60 h PS total: 150 h
Assignment to Curriculum	DSMSE (M.Sc.)

Module RM1: Research Module I

Responsibility	Study program moderator			
Content	The course content is related to the current research projects of the respective chair. The module includes experimental work, literature review, participation in group seminars, possibly with own presentation and/or preparation of a written report.			
Qualification objective	Students should gain insight into current research practice. In addition, they should acquire experimental skills through independent laboratory work under supervision, and practice teamwork and presentation techniques.			
Prerequisites	Knowledge in the fields of engineering and materials science. Ability to work independently.			
Language	English			
Possible inclusion in curriculum	Third semester			
Subject area	Research module area			
Frequency	Every semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	RM1	Research Module I	-	6LP
		Total:	-	6LP
Examination	Portfolio examination: Written elaboration (Mark weighting 3/4), Presentation (Mark weighting 1/4)			
Student workload	Modul RM1 total: 180 h			
Assignment to Curriculum	DSMSE (M.Sc.)			

Module RM2: Research Module II

Responsibility	Stuy program moderator			
Content	The course content is related to the current research projects of the respective chair. The module includes experimental work, literature review, participation in group seminars, possibly with own presentation and/or preparation of a written report.			
Qualification objective	Students should gain insight into current research practice. In addition, they should acquire experimental skills through independent laboratory work under supervision, and practice teamwork and presentation techniques.			
Prerequisites	Knowledge in the fields of engineering and materials science. Ability to work independently.			
Language	English			
Possible inclusion in curriculum	Third semester			
Subject area	Research module area			
Frequency	Every semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	RM2	Research Module II	-	6LP
		Total:	-	6LP
Examination	Portfolio examination: Written elaboration (Mark weighting 3/4), Presentation (Mark weighting 1/4)			
Student workload	Modul RM2 total: 180 h			
Assignment to Curriculum	DSMSE (M.Sc.)			

Module SPD: Simulation, Programming and Data Analysis

Responsibility	Chair of Functional Materials (Dr.-Ing. Jaroslaw Kita)			
Content	Numerical simulation of coupled physical processes; Introduction to the numerical treatment of engineering applications; Computer-aided analysis and evaluation of scientific and technical data.			
Qualification objective	Students develop hands-on skills in: Solving engineering problems using modern computer-aided analysis and modeling methods; learning and practically applying corresponding software tools.			
Prerequisites	Advanced study skills acquired in a bachelor's degree program in natural sciences or engineering Language of Instruction: English			
Language	English			
Possible inclusion in curriculum	Second or third semester			
Teaching Language	English			
Subject area	Focus area: "Digitalization in Materials Science"			
Frequency	Every semester			
Duration	1 semester			
Overview and credits	Kennung	Veranstaltung	SWS	LP
	SPD1	Numerical simulation of coupled physical processes (COMSOL)	1V+1Ü	2 LP
	SPD2	Programming for scientific and engineering applications (Matlab)	1V+1Ü	2 LP
	SPD3	Data analysis of scientific and engineering data (Origin)	1Ü	1 LP
		Total:	2V+3Ü	5 LP
Examination	Oral exam			
Student workload	○ 75 h Attendance time			

	○ 75 h Self-study and examination preparation SPD total: 150 h
Assignment to Curriculum	DSMSE (M.Sc.)

Module SEC: Social Entrepreneurship Cases: Analyzing Social Businesses

Responsibility	JP Social Entrepreneurship (Prof. Dr. Eva Jakob)			
Content	The content of the seminar will be the analysis of socially and ecologically oriented business models, the target group analysis of social businesses, the theory of change, impact measurement and the scaling of social startups / social enterprises.			
Qualification objective	In this seminar we will analyze business models of social businesses (i.e., emerging and existing companies with social and/or ecological objectives), in order to discuss challenges and success factors. After completing the module, you will be able to critically evaluate and develop business models with social and ecological effects. During the seminar you will acquire an understanding of the elements of a business model with socio-ecological goals. You will have the skill to identify the elements of a business model for an existing social business. In addition, you will be able to critically evaluate what constitutes a successful business model with economic and socio-ecological goals. Finally, you will acquire the competence to independently develop existing business models.			
Prerequisites	None.			
Language	English			
Possible inclusion in curriculum	First or second semester			
Subject area	Compulsory elective area: „Social, Economic and Legal Aspects"			
Frequency	Yearly, currently in the winter semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	SEC	Social Entrepreneurship Cases: Analyzing Social Businesses	2V + 2Ü	6LP
		Total:	2V + 2Ü	6LP
Examination	Term paper (Mark weighting 3/5) and presentation (Mark weighting 2/5).			
Student workload	o 60 h Attendance time o 120 h Self-study and examination preparation SEC total: 180 h			
Assignment to Curriculum	Business Administration (M.Sc.); Entrepreneurship & Digitalization (M.Sc.), DSMSE (M.Sc.)			

Module SBI: Sustainable Business Innovation

Responsibility	Chair of Polymer Engineering (Prof. Dr.-Ing. Holger Ruckdäschel)			
Content	The module provides an integrated, engineering-based approach to sustainable product and business model development. Sustainability is not understood as a regulatory obligation, but as a strategic logic for differentiation and innovation. The integrative methods and concepts (e.g. Cradle-to-Cradle, Circular Business Modelling) consistently align ecological and economic objectives. The content is developed interactively through practice-oriented case studies.			
Qualification objective	After successful completion of the module, students are able to: ○ analyze technical products systematically across the entire life cycle (design, use, end-of-life), ○ distinguish and prioritize R-strategies from both a technical and an economic perspective, ○ apply Design for Disassembly, Design for Reuse and Design for Recycling in a structured and methodical manner, ○ quantify material, energy and quality losses using Material Flow Cost Accounting (MFCA), ○ link ecological impacts with economic performance indicators, ○ develop circular business models, ○ systematically prepare decisions under uncertainty (e.g. price volatility, return rates, usage behavior), ○ reflect on their own role and responsibility as engineers in the context of sustainable transformation.			
Prerequisites	Advanced academic competence acquired through the successful completion of a Bachelor's degree programme in natural or engineering sciences			
Language	English			
Possible inclusion in curriculum	Second or third semester			
Subject area	Focus Area: „Circular Economy & Sustainable Raw Materials"			
Frequency	Periodically in the winter semester			
Duration	1 Semester			
Overview and credits	Kennung	Veranstaltung	SWS	LP
	SBI	Sustainable Business Innovation	2 V + 2 Ü	5 LP
		Summe:	2 V + 2 Ü	5 LP
Examination	A written exam, oral exam, presentation or written assignment			

Student workload	○ 60 h Attendance time ○ 90 h Self-study and examination preparation Total module workload (SBI): 150 hours
Assignment to Curriculum	DSMSE (M.Sc.)

Module SPM: Sustainable polymer chemistry and polymer materials (DSMSE)

Responsibility	Chair of Macromolecular Chemistry II (Prof. Dr. Seema Agarwal)			
Content	The lecture will cover the basics of sustainability pillars, sustainable polymers from natural resources, biodegradable polymers, lightweight porous and bionic (biomimetic) polymer materials, green processes for the preparation of monomers, and polymers, recycling of polymers.			
Qualification objective	Polymers contribute significantly to the three pillars of sustainability, which are environment, economy, and society. The students will be exposed to these three pillars of sustainability with the focus on the detailed knowledge about sustainability and sustainable processes in polymer chemistry, polymer applications, and their disposal.			
Prerequisites	None			
Language	English			
Possible inclusion in curriculum	Second or third semester			
Subject area	Focus area: "Circular Economy & Sustainable Raw Materials"			
Frequency	Yearly in the summer semester			
Duration	1 semester			
Overview and credits	Identification	Course	SWS	LP
	SPM	Sustainable polymer chemistry and polymer materials	2V	5LP
		Total:	2V	5LP
0Examination	Written or oral examination			
Student workload	o 75 h Attendance time o 75 h Self-study and examination preparation SPM total: 150 h			
Assignment to Curriculum	DSMSE (M.Sc.)			

Module TPI: Technopreneurship for Engineers

Responsibility	Chair of Polymer Engineering (Prof. Dr.-Ing. Holger Ruckdäschel)

<table>
<tr><td>Content</td><td>This course provides a practice-oriented introduction to an innovative technology and demonstrates how an idea can be transformed into a market-ready product. Students learn how to develop, test, and implement business ideas as well as how to create a convincing business plan. Working in interdisciplinary teams, students develop a business model for a given technology and translate it into a business plan. Support from experienced technology and business coaches, along with continuous feedback, facilitates the learning process. Collaboration in heterogeneous teams encourages the exchange of diverse disciplinary perspectives and integrates technical expertise with economic thinking, independent of the students' field of study.</td></tr>
<tr><td>Qualification objective</td><td>Technology-based start-ups often exhibit high market potential but frequently fail due to insufficient product–market fit. Students with backgrounds in business and engineering work on an early-stage technology and develop a potential business case. In doing so, they acquire competencies in business model development and validation as well as in the structured presentation of results in presentations and a business plan.</td></tr>
<tr><td>Prerequisites</td><td>Engineering-related competencies at Bachelor's level are required; prior knowledge of entrepreneurship is recommended but not mandatory.</td></tr>
<tr><td>Language</td><td>English</td></tr>
<tr><td>Possible inclusion in curriculum</td><td>First or second semester</td></tr>
<tr><td>Subject area</td><td>Compulsory elective area: "Social, Economic and Legal Aspects of Sustainability"</td></tr>
<tr><td>Frequency</td><td>Winter and Summer Semester</td></tr>
<tr><td>Duration</td><td>1 semester</td></tr>
<tr><td>Overview and credits</td><td>
<table>
<tr><th>Identification</th><th>Course</th><th>SWS</th><th>LP</th></tr>
<tr><td>TPI1</td><td>Technopreneurship for Engineers</td><td>2V</td><td>2 LP</td></tr>
<tr><td>TPI2</td><td>Technopreneurship for Engineers</td><td>2Ü</td><td>4 LP</td></tr>
<tr><td colspan="2">Sum:</td><td>4</td><td>6 LP</td></tr>
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</td></tr>
<tr><td>Examination</td><td>Semester-long tasks (semA)</td></tr>
<tr><td>Student workload</td><td>

40 h attendance time
60 h of Self-study and examination preparation
80 h development of a business plan in group work, including research activities, customer interviews, and the preparation of presentations.

Total workload: 180 hours.
</td></tr>
</table>

Assignment to Curriculum	DSMSE (M.Sc.)