HOCHSCHULE
HAMM-LIPPSTADT

MODULE MANUAL

MASTER'S STUDY PROGRAM

SUSTAINABLE MATERIALS ENGINEERING

DEGREE: MASTER OF SCIENCE

Period of validity: 1 September 2026 to 31 August 2027

Valid with the study-program examination regulations dated 15 June 2026

Module plan according to the study-program examination regulations dated 15 June 2026 (full-time)

Semester 3	Master thesis 30 ECTS					
Semester 2	Biomimetic Materials Design 5 ECTS	Sustainable Polymeric Materials and Nanotechnology 5 ECTS	Research Seminar 5 ECTS	Research Lab Course Major area of studies 10 ECTS		Scientific and Business Communication 5 ECTS
Semester 1	Advanced Biology and Bionics 5 ECTS	Advanced Organic and Polymer Chemistry 5 ECTS	Materials of Electrical Engineering 5 ECTS	Advanced Physics of Materials 5 ECTS	Advanced Mathe-matical Methods 5 ECTS	Applied Circular Economy 5 ECTS
Alignment semester		Organic Chemistry 5 ECTS		Micro- and Nanotechnology 5 ECTS		Bionics 5 ECTS
	Biology and Basic Bionics 5 ECTS		Higher Physics and Electrical Engineering 5 ECTS		Materials Characterization 5 ECTS	

Module plan according to the study-program examination regulations dated 15 June 2026 (part-time)

Semester 3	Master thesis 30 ECTS					
Semester 2	Biomimetic Materials Design 5 ECTS	Sustainable Polymeric Materials and Nanotechnology 5 ECTS	Research Seminar 5 ECTS	Research Lab Course Major area of studies 10 ECTS		Scientific and Business Communication 5 ECTS
Semester 1	Advanced Biology and Bionics 5 ECTS	Advanced Organic and Polymer Chemistry 5 ECTS	Materials of Electrical Engineering 5 ECTS	Advanced Physics of Materials 5 ECTS	Advanced Mathe-matical Methods 5 ECTS	Applied Circular Economy 5 ECTS
Alignment semester		Organic Chemistry 5 ECTS		Micro- and Nanotechnology 5 ECTS		Bionics 5 ECTS
	Biology and Basic Bionics 5 ECTS		Higher Physics and Electrical Engineering 5 ECTS		Materials Characterization 5 ECTS	

Content

Overview of the study program example regular start in the summer semester 2
Biology and Basic Bionics 3
Organic Chemistry 6
Micro- and Nanotechnology 9
Higher Physics and Electrical Engineering 11
Materials Characterization 14
Bionics 16
Advanced Biology and Bionics 20
Advanced Organic and Polymer Chemistry 22
Materials of Electrical Engineering 25
Advanced Physics of Materials 27
Advanced Mathematical Methods 29
Applied Circular Economy 32
Biomimetic Materials Design 34
Sustainable Polymeric Materials and Nanotechnology 36
Research Seminar 39
Research Lab Course 41
Scientific and Business Communication 43
Master’s thesis including master's seminar 46

Overview of the study program example regular start in the summer semester

Study plan: Full-time studies

Semester	Module Description	Module Abbreviation
1	Advanced Biology and Bionics	SME-M-2-1.01
1	Advanced Organic and Polymer Chemistry	SME-M-2-1.02
1	Materials of Electrical Engineering	SME-M-2-1.03
1	Advanced Physics of Materials	SME-M-2-1.04
1	Advanced Mathematical Methods	SME-M-2-1.05
1	Applied Circular Economy	SME-M-2-1.06
2	Biomimetic Materials Design	SME-M-2-2.01
2	Sustainable Polymeric Materials and Nanotechnology	SME-M-2-2.02
2	Research Seminar	SME-M-2-2.03
2	Research Lab Course	SME-M-2-2.05
2	Scientific and Business Communication	SME-M-2-2.04
3	Master’s thesis including master's seminar	SME-M-2-3.01

Study plan: Part-time studies

Semester	Module Description	Module Abbreviation
1	Advanced Biology and Bionics	SME-M-2-1.01
1	Advanced Organic and Polymer Chemistry	SME-M-2-1.02
1	Advanced Mathematical Methods	SME-M-2-1.05
2	Biomimetic Materials Design	SME-M-2-2.01
2	Research Seminar	SME-M-2-2.03
2	Scientific and Business Communication	SME-M-2-2.04
3	Materials of Electrical Engineering	SME-M-2-1.03
3	Advanced Physics of Materials	SME-M-2-1.04
3	Applied Circular Economy	SME-M-2-1.06
4	Sustainable Polymeric Materials and Nanotechnology	SME-M-2-2.02
4	Research Lab Course	SME-M-2-2.05
5/6	Master’s thesis including master's seminar	SME-M-2-3.01

Module Description	**Biology and Basic Bionics**
Module Abbreviation	**MSB-B-2-2.16 / SMB-B-2-2.16**
Module Coordinator	**Helge Fabritius**

ECTS Credits	5	**Total Workload**	150 hours
Weekly Contact Hrs (SWS)	4	**Attendance Hours**	60 hours
Language	English	**Self-Study Time**	90 hours

Semester / Frequency of the Course Offering / Duration	Credit alignment semester / Every winter semester / 1 semester

Objectives	The students acquire a fundamental understanding of biology and learn the initial principles and phenomena of bionics, which they apply to different issues in life sciences. They learn about the structure and function of biological macromolecules, the structure and function of cells, and the principles of evolution and systematics in the organism kingdom. They can make abstractions about this knowledge and apply it to biological and technical issues in the fields of bionics and biomimetics.
Content	Biology and Basic Bionics: - Biological fundamentals and key topics - Structure and function of biological macromolecules - Lipids and biological membranes - The structure of cells - Fundamentals of virology - Fundamentals of microbiology - Structure, function, and systematics of plants - Structure, function, and systematics of animals - Evolutionary mechanisms and the emergence of species - Metabolism, the sensory system, and motor mechanisms - Introduction and basic concepts of bionics - Principles of bionics Laboratory course: - Fundamentals of working in biological laboratories, laboratory equipment, and occupational safety - Preparation and documentation of plant tissue - Preparation and documentation of animal tissue - Presentation of biological and bionic materials
Teaching Methods	2 lecture hours per week, 1 practice course hour per week, 1 lab hour per week (4 SWS)

	Part of the courses may be held in the form of a subject-related field excursion.
Course / Teaching and Learning Methods	The educational content is generally disseminated using slides (e.g., PowerPoint) or board drawings as part of the lecture. The content is related to practice and explained using examples related to bionic topics where relevant. Students gain a deeper understanding of the lecture content during the practice courses via suitable practice problems. This gives the students the opportunity to complete the practice problems under the moderation of a lecturer. The students' open questions are discussed and answered in the group. The laboratory course serves to supplement and deepen the knowledge acquired as part of the lecture and practice course. To prepare for the laboratory course, students may have to learn about experiments and experiment techniques through independent studying using the documents provided. During the laboratory course, students conduct experiments under direction and supervision and prepare their own experiment reports at the end of the course, where appropriate.
Examination Type(s)	Module final examination as a written exam (60 minutes). Successful participation in the laboratory course "Biology and Basic Bionics" is documented via the certificates obtained for the experiment days and via the experiment protocols.
Recommendations for Participation	None
Prerequisite for Being Awarded ECTS Credits	Passed module final examination and successful participation in the laboratory course by receiving a completion certificate
Application of the Module (in Other Degree Programs)	- Materials Science and Bionics (MSB-B-2-2.16) - Sustainable Materials Engineering (SMB-B-2-2.16)
Bibliography / Literature	Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course(s) or during the lecture as they relate to the content and tasks. A selection is shown below: - W. K. Purves, et al., Biologie, Spektrum Akademischer Verlag, München. - D.Hillis et al. Life: The Science of Biology, Twelfth Edition, WH Freeman, 2020N. A. Campbell, et al., Biologie, Pearsson Studium, München. - N. A. Campbell, et al., Biology, 12th Edition, Pearsson, 2020. - M. T. Madigan, J. M. Martinko, T. D. Brock, Mikrobiologie, Pearson. - W. Reineke, M. Schlömann. Environmental Microbiology. 1st ed. 2023. Berlin, Heidelberg: Springer Berlin Heidelberg, 2023. - A. Bresinsky, Strasburger – Lehrbuch der Botanik, Spektrum Akademischer Verlag. - J. Kiogora Mworia, Botany. IntechOpen, 2012.

	- R. Wehner, W. J. Gehring, Zoologie, Georg Thieme, Stuttgart/New York. - W. Westheide, R. Rieger, Spezielle Zoologie Teil 1 & Teil 2, Spektrum Akademischer Verlag. - R. Kraft, W. Kükenthal, A. Schmidt-Rhaesa. Handbook of Zoology A Natural History of the Phyla of the Animal Kingdom / Eine Naturgeschichte der Stämme des Tierreiches, Xenarthra. Reprint 2020. Berlin ; Boston: De Gruyter, 1995. - W. Nachtigall, Bionik – Grundlagen und Beispiele für Ingenieure und Naturwissenschaftler, Springer, 2002. - F.L. Palombini, S. Senthilkannan Muthu. Bionics and Sustainable Design. 1st ed. 2022. Singapore: Springer Nature Singapore, 2022.

Module Description	**Organic Chemistry**
Module Abbreviation	**MSB-B-2-3.15 / SMB-B-2-3.15**
Module Coordinator	**Sabine Fuchs**

ECTS Credits	5	**Total Workload**	150 hours
Weekly Contact Hrs (SWS)	4	**Attendance Hours**	60 hours
Language	English	**Self-Study Time**	90 hours

Semester / Frequency of the Course Offering / Duration	Credit alignment semester / Every winter semester / 1 semester

Objectives	Students are given a sound basic understanding of organic chemistry, allowing them to infer and deduce the connections between the composition and structure of an organic molecule and its chemical and physical properties. Key synthesis routes and methods for their extraction and purification are familiar and can be implemented in practice. Students are able to apply methods to determine the structure of organic molecules and to synthesize, purify, and analyze organic compounds, and assess them in terms of their fundamental suitability in a given application. Students are familiar with the most important methods in the industrial production of organic-chemical products and are able to choose an appropriate method for producing the planned product.
Content	- Fundamentals of organic chemistry - Organic molecules - Functional groups in organic chemistry - Analytical methods in organic chemistry (TLC, HPLC, IR, NMR, EA) - Synthesis of organic molecules - Organic molecules in solution - Organic solids, liquids, and gases - Qualitative analysis of organic molecules - Reactions around organic molecules - Complete characterization of organic molecules Laboratory course “Organic Chemistry”: - Creation of covalent bonds: synthesis of functional organic compounds - Processing raw products - Purification and characterization of organic compounds - Chromatographic methods, e.g.: thin-layer chromatography, column chromatography, HPLC

	- Spectroscopic methods, e.g.: infrared spectroscopy, ultraviolet-visible spectroscopy, nuclear magnetic resonance spectroscopy - Other methods: elemental analysis, mass spectrometry
Teaching Methods	2 lecture hours per week, 1 practice course hour per week, 1 lab hour per week (4 SWS)
Course / Teaching and Learning Methods	The educational content is generally disseminated using slides (e.g., PowerPoint) or board drawings as part of the lectures. The content is related to practice and explained using examples where relevant. Students gain a deeper understanding of the lecture content during the practice courses via suitable practice problems. This gives the students the opportunity to complete the practice problems on the board under the moderation of a lecturer. The students' open questions are discussed and answered in the group. During the laboratory course, the content learned is realized and expanded using experiments. Basic techniques for conducting experiments and documenting them will be practiced with assistance.
Examination Type(s)	Module final examination as a written exam / electronic written exam (60 minutes). Successful participation in the laboratory course "Organic Chemistry" is documented via certificates obtained for the preparation and conduct of the experiments and the experiment protocols.
Recommendations for Participation	Successful participation in the "General and Inorganic Chemistry" module
Prerequisite for Being Awarded ECTS Credits	Passed module final examination and laboratory course by receiving a completion certificate.
Application of the Module (in Other Degree Programs)	- Materials Science and Bionics (MSB-B-2-3.15) - Sustainable Materials Engineering (SMB-B-2-3.15)
Bibliography / Literature	Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course(s) or during the lecture as they relate to the content and tasks. A selection is shown below: - P. Y. Bruce, Organic Chemistry, Global Edition, Pearson HigherEducation. - C. Schmuck, Basisbuch Organische Chemie, Pearson, 1. Aufl. 2013. - J. Clayden, N. Geeves, S. Warren, Organic Chemistry, Oxford University Press. - D. Klein, Organic Chemistry, International Adaptation, Wiley John & Sons. - L. G. Wade, J. W. Simek, Organic Chemistry, Pearson. - K. P. C. Vollhardt, N. E. Schorle, Organische Chemie, Wiley-VCH, Weinheim.

	- R. Weber, Arbeitstechnik im Chemielabor, Haupt, UTB. - K. Schwetlick, E. Fanghänel, Organikum: Organisch-chemisches Grundpraktikum, Wiley-VCH, Weinheim.

Module Description	**Micro- and Nanotechnology**
Module Abbreviation	**MSB-B-2-7.18 / SMB-B-2-7.18**
Module Coordinator	**Christian Thomas**

ECTS Credits	5	**Total Workload**	150 hours
Weekly Contact Hrs (SWS)	4	**Attendance Hours**	60 hours
Language	English	**Self-Study Time**	90 hours

Semester / Frequency of the Course Offering / Duration	Credit alignment semester / Every winter semester / 1 semester

Objectives	The students are familiar with different methods for characterizing and structuring in the micro- and nanometer range. They are able to select the appropriate characterization method depending on the problem and assessing the results. The students can plan the process steps for structuring and processing in the micro- and nanometer range in a needs-based and targeted manner.
Content	Micro- and Nanotechnology: - Micro- and nano-characterization techniques, such as: Optical microscopy techniques: Electron microscopy Ion beam microscopy X-ray tomography Scanning probe techniques - Micro- and nano-structuring techniques, such as: Photolithography Laser microstructuring Electron-beam lithography Ion beam techniques (FIB ablation and deposition) Printing techniques Nanoimprint lithography (NIL) AFM-based lithography (nanoshaving, nanografting, and dip-pen nanolithography) Assessed coursework: - Sample preparation - Electron-beam lithography

	Characterization of micro- and nano-structures with the help of spectroscopic methods, optical and electron microscopy, AFM, and monochromators
Teaching Methods	Micro- and Nanotechnology: 2 lecture hours per week, 2 lab hour per week (4 SWS) Laboratory courses as an assessed coursework. Part of the courses may be held in the form of a subject-related field trip (such as a course day).
Course / Teaching and Learning Methods	The educational content is generally disseminated using slides or board drawings as part of the seminar lectures. The content is related to practice, explained through examples where relevant, and expanded by suitable exercises. The students' open questions are discussed and answered in the group. The laboratory course serves to supplement and deepen the knowledge acquired as part of the lecture. To prepare for the laboratory course, students may have to learn about experiments and experiment setups through independent studying using the documents provided. During the laboratory course, students conduct experiments under the direction and supervision of the lecturer and prepare their own experiment reports at the end of the course, where appropriate.
Examination Type(s)	During the winter semester: Module final examination consisting of a written exam (30 minutes) and a presentation on micro- and nanotechnology (20 minutes). During the summer semester: Module final examination consisting of an oral exam (30 minutes).
Recommendations for Participation	None
Prerequisite for Being Awarded ECTS Credits	Passed module final examination and successful participation in the laboratory course (assessed coursework)
Application of the Module (in Other Degree Programs)	- Materials Science and Bionics (MSB-B-2-7.18) - Sustainable Maerials Engineering (SMB-B-2-7.18)
Bibliography / Literature	Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course(s) or during the lecture as they relate to the content and tasks. A selection is shown below: - S. Globisch, Lehrbuch Mikrotechnologie [Microtechnology textbook], Hanser. - W. Menz, J. Mohr, O. Paul, Mikrosystemtechnik für Ingenieure [Microsystems technology for engineers], Wiley. - R. Waser, Nanoelectronics and Information Technology, Wiley. - Joseph I. Goldstein et al., Scanning Electron Microscopy and Microanalysis, Springer.

Module Description	**Higher Physics and Electrical Engineering**
Module Abbreviation	**MSB-B-2-2.20 / SMB-B-2-6.31**
Module Coordinator	**Christian Thomas**

ECTS Credits	5	**Total Workload**	150 hours
Weekly Contact Hrs (SWS)	5	**Attendance Hours**	75 hours
Language	English	**Self-Study Time**	75 hours

Semester / Frequency of the Course Offering / Duration	Credit alignment semester / Every winter semester / 1 semester

Objectives	Thermodynamics and Atomic Physics: Building on the “Fundamentals of Physics” course, the students acquire an understanding of special topics of higher physics and electrical engineering. They are able to apply tools and techniques to grasp the structure of atoms, the effects of phenomenological and statistical thermodynamics, and fundamental electrical processes and components with the aid of the knowledge gained. Students learn the first basic properties of light and the fundamental light-matter interaction. They are able to apply their knowledge to basic questions about optics. Fundamentals of Electrical Engineering: Students are familiar with the basic physical concepts of electrical engineering and master methods for analyzing and calculating direct current networks. They are familiar with the concept of fields and have the skills to describe stationary electrical and magnetic fields. The students are able to calculate the electric field distributions of simple charging assemblies and know different capacitor assemblies.
Content	Thermodynamics and Atomic Physics: - Matter in the microcosm and macrocosm, special aspects of atomic physics - Fundamentals of thermodynamics: temperature, heat, and internal energy - The first law of thermodynamics, ideal gas, volume work - Second law of thermodynamics - Introduction to thermodynamics: the concept of phenomenological and statistical thermodynamics - Ideal and real gases (Van der Waals equation)

	- Thermodynamic potentials (enthalpy, free enthalpy, Helmholtz and Gibbs free energy) and chemical potential - Phase transitions and critical phenomena - Fundamental light-matter interaction - Atomic polarization and magnetization of materials, optical refractive index, dielectrics - Electrical and magnetic susceptibility, permeability - Basic properties of optical materials by linear and non-linear matter response Fundamentals of Electrical Engineering: - Physical quantities in electrical engineering - Direct current and linear DC networks - Kirchhoff's circuit laws - Capacitors and capacitance - Coils and inductance - Alternating current and resistance and impedance - LC circuits - Measuring electrical engineering quantities - Simple electronic components (diodes, transistors)
Teaching Methods	Thermodynamics and Atomic Physics: 1 lecture hour per week, 1 practice course hour per week (2 SWS) Fundamentals of Electrical Engineering: 2 lecture hours per week, 1 practice course hour per week (3 SWS)
Course / Teaching and Learning Methods	Seminar-style lecture. The foundations for the advanced natural sciences and engineering disciplines are disseminated using current examples from practice and with respect to current topics. Short practice problems are integrated into the lecture. Projectors and whiteboards are on hand as technical support. The practice problems are prepared in teams and the solutions are preferably presented by the students. By preparing selected practice problems as coursework during the semester, bonus points can be awarded in accordance with Section 16 (5-7) of the General Examination Regulations (RPO). Details will be announced during the first course and then published on the learning platform.
Examination Type(s)	Module final examination as an electronic written exam (120 minutes) [typical case] or an oral exam (30 minutes)* * The specific examination type will be announced during the first course as well as via the learning platform before the end of the registration period of the respective semester.
Recommendations for Participation	Knowledge from Fundamentals of Physics
Prerequisite for Being Awarded ECTS Credits	Passed module final examination

Application of the Module (in Other Degree Programs)	- Materials Science and Bionics (MSB-B-2-2.20) - Sustainable Materials Engineering (SMB-B-2-6.31)
Bibliography / Literature	Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course(s) or during the lecture as they relate to the content and tasks. A selection is shown below: Thermodynamics and Atomic Physics: - P. A. Tipler, G. Mosca, P. Kersten (Hrsg.), Physik für Wissenschaftler und Ingenieure, 8. Aufl., Springer. - C. Strunk, Moderne Thermodynamik – Von einfachen Systemen zu Nanostrukturen, De Gruyter, 2015. - D. Giancoli, Physics for Scientists and Engineers (with modern Physics),Global Edition, 2010 - D. Kondepudi, I. Prigogine, Modern Thermodynamics – From Heat Engines to Dissipative Structures, John Wiley & Sons, 1998. Fundamentals of Electrical Engineering: - R. Kories, H. Schmidt-Walter, Taschenbuch der Elektrotechnik [Pocketbook of electrical engineering], 3rd ed., Harri Deutsch, 1998. - G. Hagmann, Grundlagen der Elektrotechnik [Fundamentals of electrical engineering], Aula. - W. Nerreter, Grundlagen der Elektrotechnik für Maschinenbau und Mechatronik [Fundamentals of electrical engineering for mechanical engineering and mechatronics], Hanser. - F. Hüning, The Fundamentals of Electrical Engineering for Mechatronics, De Gruyter Oldenbourg, 2014

Module Description	**Materials Characterization**
Module Abbreviation	**MSB-B-2-2.17 / SMB-B-2-2.17**
Module Coordinator	**Jörg Meyer**

ECTS Credits	5	**Total Workload**	150 hours
Weekly Contact Hrs (SWS)	4	**Attendance Hours**	60 hours
Language	English	**Self-Study Time**	90 hours

Semester / Frequency of the Course Offering / Duration	Credit alignment semester / Every winter semester / 1 semester

Objectives	Students are familiar with different methods for characterizing materials. They are able to select the appropriate characterization method depending on the problem statement and to assess the results. Moreover, they are able to describe spectroscopic methods in different wavelength ranges and understand the setup and measurement methodology of various spectrometers. Students learn about analysis methods for non-destructive imaging and their areas of application. They understand the basic principles of thermal analysis.
Content	- Review of the Instrumental Analysis lecture - Fluorescence spectroscopy - Infrared spectroscopy - Raman spectroscopy - Nuclear magnetic resonance spectroscopy - Mass spectrometry - Thermogravimetric analysis - Differential scanning calorimetry Assessed coursework “Materials Characterization”: Optical and Electron Microscopy: - Sample preparation (biological and material samples) - Principle and setup of an optical microscope - Examinations using an optical microscope - Principle and setup of a scanning electron microscope - Examinations using a scanning electron microscope
Teaching Methods	2 lecture hours per week, 1 practice course hour per week, 1 lab hour per week (4 SWS)
Course / Teaching and Learning Methods	The educational content is generally disseminated using slides or board drawings as part of the seminar lectures. The content is related to practice, explained through examples where relevant,

	and expanded by suitable exercises. The students' open questions are discussed and answered in the group. The laboratory course serves to supplement and deepen the knowledge acquired as part of the lecture. To prepare for the laboratory course, students may have to learn about experiments and experiment setups through self learning using the documents provided. During the laboratory course, students conduct experiments under the direction and supervision of the lecturer and prepare their own experiment reports at the end of the course, where appropriate.
Examination Type(s)	Module final examination as a written exam (60 minutes)
Recommendations for Participation	None
Prerequisite for Being Awarded ECTS Credits	Passed module final examination and successful participation in the assessed coursework "Materials Characterization"
Application of the Module (in Other Degree Programs)	- Materials Science and Bionics (MSB-B-2-2.17) - Sustainable Materials Engineering (SMB-B-2-2.17)
Bibliography / Literature	Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course(s) or during the lecture as they relate to the content and tasks. A selection is shown below: - D. A. Skoog, F. J. Holler, S. R. Crouch, Instrumentelle Analytik: Grundlagen – Geräte – Anwendungen [Instrumental analysis: Basics – Devices – Applications], ed. by R. Nießner, Springer Spektrum, 2013. - D. A. Skoog, F. J. Holler, S. R. Crouch, Principles of instrumental analysis, 7. edition; Cengage Learning, 2018. - P. J. Haines, Ed., Principles of Thermal Analysis and Calorimetry, RSC paperbacks, Royal Society of Chemistry, Cambridge, 2002. - K. Schiebold, Ed., Zerstörungsfreie Werkstoffprüfung – Durchstrahlungsprüfung [Non-destructive testing – Radiographic testing], Springer, Berlin/Heidelberg, 2015. - K. Schiebold, Zerstörungsfreie Werkstoffprüfung – Ultraschallprüfung [Non-destructive testing – Ultrasonic testing], SpringerLink: books, Springer Vieweg, Berlin/Heidelberg, 2015.

Module Description	**Bionics**
Module Abbreviation	**MSB-B-2-3.16 / SMB-B-2-3.16**
Module Coordinator	**Oliver Sandfuchs**

ECTS Credits	5	**Total Workload**	150 hours
Weekly Contact Hrs (SWS)	4	**Attendance Hours**	60 hours
Language	English	**Self-Study Time**	90 hours

Semester / Frequency of the Course Offering / Duration	Credit alignment semester / Every winter semester / 1 semester

Objectives	Due to the “Biology and Basic Bionics” lecture, students possess knowledge of the initial principles and phenomena of bionics. They learn the basic concepts and methods of bionics. They are able to recognize the functional mechanisms of nature, associate these mechanisms with technical challenges, and to derive initial solutions and technological strategies from them. As part of the seminar, students learn to independently familiarize themselves with new questions, conduct research on bionic topics, and present and explain these topics to their fellow students in the form of a seminar presentation. As part of the laboratory course, students gain practical experience in the fields of surfaces and adhesive mechanisms in bionics, gripping and movement in bionics using selected practical examples, and optical structures and bionics. They have knowledge of planning experiments, writing documentation, and presenting and analyzing experimental results. Cross-disciplinary skills in lightweight construction are taught. The laboratory course has the role of preparing students for implementing projects in lightweight construction, among other things. During the laboratory experiment on surfaces and adhesive mechanisms, joining techniques for lightweight construction production using bionic examples (e.g., burdock) are developed in the group. During the gripping and movement experiment, movement patterns in nature are analyzed to use them in bionically inspired technical applications such as lightweight grippers (based on, e.g., elephant trunks, octopuses, etc.). In the laboratory experiments on biomimetic optics, students are introduced to the optical surfaces and structures that occur in nature in animal eyes and in the exoskeletons of insects, for

	example, and they are capable of characterizing them based on simple microscopic analysis methods and understand their functioning. They gain basic knowledge of micro and nanotechnologies in relation to biological optical systems and their abstractions in technical applications.
Content	Bionics and Fundamental Bionic Processes: - Basic principles of bionics, biomimetics, technical biology, and biophysics - Structuring like plants, the principle of tensile triangles, the golden ratio - Fundamentals of the functioning of animal vision organs and their bionic and biomimetic applications - Basic principles of swarm intelligence (e.g., of ants) and swarm behavior (e.g., of fish and bees) - Laws, strategies, and principles of nature - Bionic technological solutions and processes - System optimization and evolutionary principles of the second kind: fundamentals of self-organization and epigenetics - Optimization and saturation in nature (e.g., Lotka-Volterra predator-prey mode) - Critical system behavior and bifurcation - Self-organization using the examples of heat convection, the laser process in photonics, and simple autocatalytic chemical reactions - Special topics in bionics such as: - Interaction with surfaces: lotus effect and water striders - Noise insulation: flying like owls - The bumble-bee paradox: why they actually can fly - Adaptive construction like plants - Coordination control: walking like stick insects - Overcoming resistance: swimming like sharks and gliding like sandfish skinks - Natural sun protection: the hair of desert ants - Eyes in land mammals and fish - Insect eyes (e.g., flies and moths) - Moving detectors, the vibration camera of the jumping spider - Mirror lenses and polarization optics in crayfish and mantis shrimp eyes Laboratory course “Bionics”: - Surfaces and adhesive mechanisms in bionics: determination of surface properties using a contact angle measurement device, examination of various adhesive mechanisms

	- Gripping and movement in bionics: analysis of movement patterns in nature and their translation to a technical problem - Nanostructures and bionics: measuring biomimetic nanostructures with the help of SEM, measurement and function of biomimetic surface structures in animal eyes - Optics and Bionics: optical behavior of biological structures, optical microscopy, changing the optical response as a reaction to external stimuli, mechanochromic properties of beetle scales
Teaching Methods	2 lecture hours per week, 1 seminar hour per week, 1 lab hour per week (4 SWS)
Course / Teaching and Learning Methods	The educational content is generally disseminated using slides or board drawings as part of the lectures. The content is related to practice and explained using examples where relevant. Students prepare individual topics in independent studying and present these topics as part of the lecture and then discuss them.
Examination Type(s)	Module final examination as a written exam / electronic written exam (90 minutes)* Successful participation in the laboratory course "Bionics" is documented via professor's signatures, experiment certificates, and a 20-minute graded final presentation that is documented by a completion certificate.* As part of the seminar, this module includes one performance assessment during the semester in the form of a group presentation on special topics in bionics. The weighting of the seminar to the written exam is 35% to 65%. * The specific examination type will be announced during the first course as well as via the learning platform before the end of the registration period of the respective semester. The examination regulations determine the weighting between the main module and the submodule.
Recommendations for Participation	Successful participation in the "Biology and Basic Bionics" module
Prerequisite for Being Awarded ECTS Credits	Passed module final examination and laboratory course by receiving a completion certificate.
Application of the Module (in Other Degree Programs)	- Materials Science and Bionics (MSB-B-2-3.16) - Sustainable Materials Engineering (SMB-B-2-3.16)
Bibliography / Literature	Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course(s) or during the lecture as they relate to the content and tasks. A selection is shown below:

	- W. Nachtigall and A. Wisser, Bionics by Examples, Springer-Verlag, 2014 - J. M. Benyus, Biomimicry – Innovation Inspired by Nature, Harper, 1998. - A. Parker, In the blink of an eye, Basic-Books, 2003. - Ph. Ball, The Self-Made Tapestry – Pattern formation in Nature, Oxford Univ. Press, 1999. - G. Menges, Werkstoffkunde Kunststoffe, Carl Hanser, München. - G. Krüger, Klettverschlüsse – Materialien, Herstellung, Prüfung, Anwendungen, 1. Aufl., Hanser, München, 2013. - G. Habenicht, Kleben – Grundlagen, Technologien, Anwendungen, Springer. - M. A. Meyers, P.-Y. Chen, Biological Materials Science, Cambridge University Press, 2014. - P. Fratzl et al., Materials Design Inspired by Nature: Function Through Inner Architecture, RSC Publishing, 2013.

Module Description	**Advanced Biology and Bionics**
Module Abbreviation	**SME-M-2-1.01**
Module Coordinator	**Helge Fabritius**

ECTS Credits	5	**Total Workload**	150 hours
Weekly Contact Hrs (SWS)	2	**Attendance Hours**	30 hours
Language	English	**Self-Study Time**	120 hours

Semester / Frequency of the Course Offering / Duration	1st study semester / Every summer semester / 1 semester

Objectives	Students expand and deepen their basic knowledge gained during their bachelor's program of the composition and function of biological macromolecules, the structure and function of cells, systematics in the animal kingdom, and the principles and phenomena of bionics through a detailed understanding of biosynthesis, structure, and properties of biological materials. They understand natural processes in the creation of material and are able to associate them with technical challenges and derive sustainable solutions and technological strategies from them. They are familiar with the different types of biological materials and are able to transfer sustainable material concepts from nature and their functional principles to bio-inspired/biomimetic technical materials.
Content	- Basic biology principles - Self-assembly, hierarchy, and evolution - Basic building blocks: biopolymers - Cells and cell types - Biomineralization - Silicate-based composites - Calcium-carbonate-based composites - Calcium-phosphate-based composites - Biological polymers and polymer composites - Biological elastomers - Biological foams (cellular solids) - Functional biological materials
Teaching Methods	2 lecture hours per week (2 SWS)
Course / Teaching and Learning Methods	The educational content is generally disseminated using slides (e.g., PowerPoint) or board drawings as part of the lecture. The content is related to practice and explained through examples taken from the

	current specialized literature. Open questions are discussed and answered in the group.
Examination Type(s)	Module final examination as a written exam (60 minutes)
Recommendations for Participation	Successful participation in the module: Biology and Basic Bionics After consultation with the lecturer, the basic knowledge in selected fields can be acquired during independent studying on a case-by-case basis.
Prerequisite for Being Awarded ECTS Credits	Passed module final examination (see examination types)
Application of the Module (in Other Degree Programs)	None
Bibliography / Literature	Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course(s) or during the lecture as they relate to the content and tasks. A selection is shown below: - W. Nachtigall, A. Wisser, Bionik – Bionics by Examples – 250 Scenarios from Classical to Modern Times, Springer, 2015. - M. A. Meyers, P.-Y. Chen, Biological Materials Science, Cambridge University Press, 2014. - P. Fratzl et al., Materials Design Inspired by Nature: Function Through Inner Architecture, RSC Publishing, 2013.

Module Description	**Advanced Organic and Polymer Chemistry**
Module Abbreviation	**SME-M-2-1.02**
Module Coordinator	**Sabine Fuchs**

ECTS Credits	5	**Total Workload**	150 hours
Weekly Contact Hrs (SWS)	3	**Attendance Hours**	45 hours
Language	English	**Self-Study Time**	105 hours

Semester / Frequency of the Course Offering / Duration	1st study semester / Summer semester / 1 semester

Objectives	Students expand and deepen their basic knowledge gained during their bachelor's program and their understanding of the reactivity of organic compounds by using refined concepts. They are capable of connecting important cross-relationships in their knowledge and especially of applying the principles of reactivity and modern concepts across a wide range of reactions. The students are able to assess and evaluate specific reactivity and synthesis problems in organic chemistry. They are able to apply their conceptual knowledge of the reactivity of organic compounds to solve new issues and problems. Based on this, students learn the fundamentals of polymer chemistry and different polymerization types including chain and step-growth polymerization. An overview of the relevant polymers, the central methods for characterizing polymers, and the basic characteristics of polymers in both solution and solids will be taught. The students are able to: - Reproduce the fundamental physical characteristics and material characteristics of polymers and the special features of polymers compared to other material classes, especially to small molecules, - Learn the basics of polymer chemistry, polymerization types, chain and step growth, - Critically assess polymerization methods, both in terms of the achievable molecular weights and the respective limitations of polydispersity, - Become familiar with fundamental characterization methods and assess them in terms of their suitability to specific questions, - Conceptually understand the structure and dynamics of macromolecules and discuss them quantitatively

Content	- Molecular structure and basic concepts - Structural effects on stability and reactivity - Nucleophilic substitutions, polar addition, and elimination reactions - Free radical reactions - Functional group interconversion by substitution, including protection and deprotection - Electrophilic additions to carbon-carbon multiple bonds - Concerted cycloadditions, unimolecular rearrangements, and thermal eliminations - Multi-step syntheses - Polymers in solution and in solid state - Partially crystalline and amorphous polymers - Radical polymerizations, ionic polymerizations, coordination polymerizations, and ring-opening polymerizations - Co-polymerizations - Chemistry with polymers - Industrially relevant polymerization processes - Functional polymers - Liquid crystalline polymers - Polymers and the environment - Current trends in polymer science
Teaching Methods	1 lecture hour per week, 1 practice course hour per week, 1 lab hour per week (3 SWS)
Course / Teaching and Learning Methods	The educational content is generally disseminated using slides (e.g., PowerPoint) or board drawings as part of the lectures. The content is related to practice and explained using examples where relevant. Students gain a deeper understanding of the lecture content during the practice courses via suitable practice problems. This gives students the opportunity to present the solutions to the practice problems on the board under the moderation of a lecturer. The laboratory course serves to supplement and deepen the knowledge acquired as part of the lecture and practice course. To prepare for the laboratory course, students may have to learn about experiments and experiment setups through independent studying using the documents provided. During the laboratory course, students conduct experiments under direction and supervision and prepare their own experiment reports at the end of the course, where appropriate.
Examination Type(s)	Module final examination as a written exam (60 minutes) Successful participation in the laboratory course “Advanced Organic and Polymer Chemistry” is documented via certificates obtained for the experiment days and via the experiment protocols.

	Weighting of each partial performance for the final grade: 70 : 30 (lecture/practice course : laboratory course).
Recommendations for Participation	- Knowledge of organic chemistry: understanding the structure, nomenclature, and reactivity of organic molecules including the associated fundamental reaction mechanisms - Knowledge of Macromolecular Chemistry and Polymer Chemistry: understanding the structure, nomenclature, and reactivity of macromolecules / polymers including the associated fundamental reaction mechanisms After consultation with the lecturer, the basic knowledge in selected fields can be acquired during independent studying on a case-by-case basis.
Prerequisite for Being Awarded ECTS Credits	Passed module final examination (see examination types)
Application of the Module (in Other Degree Programs)	None
Bibliography / Literature	Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course(s) or during the lecture as they relate to the content and tasks. A selection is shown below: - F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part A: Structure and Mechanisms, Springer-Verlag, 2007. - F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, Part B: Reactions and Synthesis, Springer-Verlag, 2007. - R. Bruckner, Advanced Organic Chemistry, Elsevier 2002. - S. Koltzenburg, M. Maskos, O. Nuyken, Polymer Chemistry, Springer-Verlag, 2017. - A. Peacock, A. Calhoun, Polymer Chemistry: Properties and Applications, Carl Hanser Fachbuchverlag, 2012. - S. Seiffert, Physical Chemistry of Polymers: A Conceptual Introduction, DeGruyter, 2020.

Module Description	**Materials of Electrical Engineering**
Module Abbreviation	**SME-M-2-1.03**
Module Coordinator	**Nicolas Heuck**

ECTS Credits	5	**Total Workload**	150 hours
Weekly Contact Hrs (SWS)	4	**Attendance Hours**	60 hours
Language	English	**Self-Study Time**	90 hours

Semester / Frequency of the Course Offering / Duration	1st study semester / Summer semester / 1 semester

Objectives	The students learn the most important materials in electrical engineering and electronics and are capable of systematizing them based on physical characteristics. They are able to assess and compare materials in electrical engineering and electronics in terms of their potential areas of application. Students acquire the ability to connect knowledge in materials science with the requirements of electrical engineering and electronics to find needs-based solutions for the realization of the relevant component.
Content	- Electrical properties of semiconductors: energy band model, Fermi–Dirac distribution, intrinsic conduction, and doping - Generation of charge carriers, recombination, and charge carrier lifetime - Semiconductor devices: p–n junction, diode, MOSFET - Electrical properties of metals - Materials and process technologies for electronic packaging (soldering, wire bonding, sintering) - Electrical properties of insulators: polarization mechanisms, polarizability and dielectric constant, electrical breakdown - Piezoelectricity and ferroelectricity
Teaching Methods	2 lecture hours per week, 1 practice course hour per week, 1 lab hour per week (4 SWS)
Course / Teaching and Learning Methods	The educational content is generally disseminated using slides or board drawings as part of the seminar lectures. The content is related to practice, explained through examples where relevant, and expanded by suitable exercises. The students' open questions are discussed and answered in the group. The laboratory course serves to supplement and deepen the knowledge acquired as part of the lecture. To prepare for the laboratory course, students may have to learn about experiments and experiment setups through independent studying using the documents provided. During the

	laboratory course, students conduct experiments under the direction and supervision of the lecturer and prepare their own experiment reports at the end of the course, where appropriate.
Examination Type(s)	Module final examination consisting of an oral exam (30 minutes)
Recommendations for Participation	- Fundamentals of Physics - Fundamentals of Electrical Engineering After consultation with the lecturer, the basic knowledge in selected fields can be acquired during independent studying on a case-by-case basis.
Prerequisite for Taking the Exam	Successful participation in the laboratory experiments.
Prerequisite for Being Awarded ECTS Credits	Passed module final examination (see examination types)
Application of the Module (in Other Degree Programs)	None
Bibliography / Literature	Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course(s) or during the lecture as they relate to the content and tasks. A selection is shown below: - G. Fasching, Werkstoffe für die Elektrotechnik – Mikrophysik, Struktur, Eigenschaften, 4th ed., Springer, 2005. - S. Kasap, P. Capper (Eds.), Springer Handbook of Electronic and Photonic Materials, 2nd ed., Springer, 2017. - Y. M. Poplavko, Electronic Materials – Principles and Applied Science, Elsevier, 2019. - K.-H. Cordes, A. Waag, N. Heuck, Integrierte Schaltungen – Grundlagen – Prozesse – Design, Pearson, 2010. - S. M. Rezende, Introduction to Electronic Materials and Devices, Springer, 2022.

Module Description	**Advanced Physics of Materials**
Module Abbreviation	**SME-M-2-1.04**
Module Coordinator	**Oliver Sandfuchs**

ECTS Credits	5	**Total Workload**	150 hours
Weekly Contact Hrs (SWS)	4	**Attendance Hours**	60 hours
Language	English	**Self-Study Time**	90 hours

Semester / Frequency of the Course Offering / Duration	1st study semester / Summer semester / 1 semester

Objectives	The students have knowledge of the phenomena and parameters concerning solid-state physics and soft-matter physics as well as the interaction of electromagnetic radiation with matter. They are familiar with the basic concepts and can apply methods for describing the properties of materials and calculate using formulas. They are able to relate this information to technical problems and derive initial solutions and modern technological strategies to develop sustainable materials.
Content	- Fundamentals of solid-state physics - Mechanical properties of solids - Thermal and thermoelectric properties of solids, thermal conductivity - Soft-matter physics: kinematic and dynamic viscosity, drift and diffusion, Fick's law - Fundamentals of quantum-mechanical phenomena in solids - Fundamentals of the interaction of light from electromagnetic radiation with matter - Linear and non-linear susceptibility of materials - Dielectrical and ferro-/para-/diamagnetic behavior of substances - Micro-/Nano-optical properties of materials - Structure-induced materials: effective media, photonic crystal structures
Teaching Methods	2 lecture hours per week, 2 practice course hours per week (4 SWS)
Course / Teaching and Learning Methods	The educational content is generally disseminated using slides or board drawings as part of the lectures. The content is related to practice and explained using examples where relevant. Individual topics are prepared by students in independent studying in the form of practice exercises and presented and discussed by students as part of the practice course.

Examination Type(s)	Module final examination as a written exam / electronic written exam* (90 minutes). The examination can also take place orally (30 minutes)*. * The specific examination type will be announced during the first course as well as via the learning platform before the end of the registration period of the respective semester.
Recommendations for Participation	Fundamentals of Physics, Higher Physics, Materials Science, Fundamentals of Quantum Mechanics, and Photonics are recommended.
Prerequisite for Being Awarded ECTS Credits	Passed module final examination (see examination types)
Application of the Module (in Other Degree Programs)	None
Bibliography / Literature	Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course(s) or during the lecture as they relate to the content and tasks. A selection is shown below: - P. Hofmann, Solid State Physics, Wiley-VCH 2022 - D. Kondepudi and I. Prigogine, Modern Thermodynamics – From Heat Engines to Dissipative Structures, John-Whiley 2015 - R. Gross, A. Marx, Festkörperphysik, 3. Aufl., De Gruyter, 2018. - C. Strunk, Moderne Thermodynamik – von einfachen Strukturen zu Nanostrukturen, De Gruyter, 2015. - S. Sinzinger, J. Jahns, Microoptics, Wiley & Sons, 2006. - P. Günter, Nonlinear Optical Effects and Materials, Springer, 2000.

Module Description	**Advanced Mathematical Methods**
Module Abbreviation	**SME-M-2-1.05**
Module Coordinator	**Kai Gehrs**

ECTS Credits	5	**Total Workload**	150 hours
Weekly Contact Hrs (SWS)	2	**Attendance Hours**	30 hours
Language	English	**Self-Study Time**	120 hours

Semester / Frequency of the Course Offering / Duration	1st study semester / Summer semester / 1 semester

Objectives	The students classify and solve differential equations using standard methods such as separation of variables and methods for homogeneous and inhomogeneous linear differential equations to evaluate particularly relevant scientific and engineering issues in practice. The students calculate Laplace and Fourier transforms and apply relevant mathematical laws and structure theorems for these, e.g., to solve initial value problems. The students combine the fundamentals of statistics and probability theory by modeling discrete as well as continuous, single-step as well as multi-step scenarios of random experiments to be able to apply widely used probability distributions and gain insights into new distributions from areas of current research. Moreover, they are able to independently develop new probability distributions in suitable software packages such as MATLAB and applying them to practical issues (e.g., in the field of describing lifespan phenomena).
Content	- Methods for solving selected classes of linear and non-linear ordinary differential equations - Initial and boundary value problems - Special and generalized functions (e.g., Heaviside step functions, special impulse, Dirac delta function) - Theory of the Laplace transform (relevant definitions, basic properties, and selected structure theorems) and applications especially relevant to solving initial value problems - Theory of the Fourier transform (relevant definitions, basic properties, and selected structure theorems) and

	applications especially relevant to solving initial value problems - Theory of discrete and continuous single-step and multi-step random experiments - Standard distributions (discrete and continuous) as well as new distributions from the area of current research such as special, multivariate Weibull distributions and strategies for their implementation in software packages (e.g., MATLAB) - Procedures for estimating and testing parameters and distributions of data (e.g., maximum likelihood estimation, chi-squared test, Kolmogorov–Smirnov test) - Generating random numbers according to a predetermined distribution for simulation purposes (e.g., inverse transform sampling)
Teaching Methods	2 seminar hours per week (2 SWS)
Course / Teaching and Learning Methods	As part of the seminar, the theoretical foundations are prepared by the participating students in the form of scripts provided by the lecturer during the intended period of self-study. During the presence hours, assignment packages and small programming projects are addressed individually or even in small groups. During this time, the lecturer is available to answer questions and provide support for students doing their work. Afterward, the results are discussed in a plenary or even shown to the entire class by individual students in the form of a short presentation.
Examination Type(s)	Module final examination as a written exam (90 minutes)
Recommendations for Participation	- Knowledge of differential and integral calculus (especially improper integrals) of one and more variables is a prerequisite - Familiarity with working with complex numbers is essential - The basics of elementary combinatorics and probability theory are assumed to be known - There should be elementary knowledge of using software for scientific computing and data processing (e.g., MATLAB, Python, R, or even Excel) After consultation with the lecturer, the basic knowledge in selected fields can be acquired during independent studying on a case-by-case basis.
Prerequisite for Being Awarded ECTS Credits	Passed module final examination (see examination types)
Application of the Module (in Other Degree Programs)	None

Bibliography / Literature	For the self-study phases, a script (in English) will be provided by the lecturer on the learning platform as part of the module. Further recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course(s) or during the seminar as it relates to the content and tasks.

Module Description	**Applied Circular Economy**
Module Abbreviation	**SME-M-2-1.06**
Module Coordinator	**Christoph Puls**

ECTS Credits	5	**Total Workload**	150 hours
Weekly Contact Hrs (SWS)	3	**Attendance Hours**	30 hours
Language	English	**Self-Study Time**	120 hours

Semester / Frequency of the Course Offering / Duration	1st study semester / Summer semester / 1 semester

Objectives	The students learn the different technical solutions of the "Circular Economy" and are able to evaluate them from an economic perspective. Moreover, the students acquire theoretical and practical knowledge to present in English and to be able to moderate the subsequent discussions and questions in English. This will prepare them for situations that are common in their daily professional lives later.
Content	Includes: - Basics of the concept "sustainability" (especially economic, ecological, and social objectives) - Content delimitation and relevance of the circular economy - Circular economy as a concept of sustainable development (including legal basis and economic significance) - The relevance of digitalization for the circular economy - Analysis of selected case studies - Obstacles and limits of the circular economy
Teaching Methods	1 lecture hour per week, 2 seminar hours per week (3 SWS)
Course / Teaching and Learning Methods	The educational content is generally disseminated using slides or board drawings as part of the lecture. The content is related to practice and explained using examples where relevant. Students regularly receive targeted references to literature, which can be used to increase their knowledge of the content covered in the lectures during their independent study time. In addition to the lecture, there is also a seminar: i.e., individual and group work, presentations, reflection and feedback discussions that are prepared by the students as part of self study.

Examination Type(s)	Seminar paper during the semester (approx. 8-10 pages) and a presentation (15 minutes). Weighting of each partial performance for the final grade: 50 : 50.
Recommendations for Participation	None
Prerequisite for Being Awarded ECTS Credits	Passed module final examination (see examination types)
Application of the Module (in Other Degree Programs)	None
Bibliography / Literature	Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course(s) or during the lecture as they relate to the content and tasks. A selection is shown below: - M. Hauff, Grundwissen Circular Economy: Vom internationalen Nachhaltigkeitskonzept zur politischen Umsetzung [Basic knowledge of the circular economy: From the international concept of sustainability to political implementation], UTB, 2024. - A. Alvarez-Risco, S. S. Muthu, S. Del-Aguila-Arcentales, Circular Economy - Impact on Carbon and Water Footprint, Springer, 2022. - W. Lehmacher, J. Bödecker, Circular Economy: 7. Industrielle Revolution: Der Weg zu mehr Nachhaltigkeit durch Kreislaufwirtschaft [Circular economy: 7th Industrial Revolution: The path to greater sustainability through a circular economy], Springer, 2023.

Module Description	**Biomimetic Materials Design**
Module Abbreviation	**SME-M-2-2.01**
Module Coordinator	**Helge Fabritius**

ECTS Credits	5	**Total Workload**	150 hours
Weekly Contact Hrs (SWS)	2	**Attendance Hours**	30 hours
Language	English	**Self-Study Time**	120 hours

Semester / Frequency of the Course Offering / Duration	2nd study semester / Winter semester / 1 semester

Objectives	Students combine their fundamental knowledge of biological and technical materials and their respective synthesis routes to develop new, sustainable material concepts for various technical applications. They are able to incorporate sustainable concepts and bio-inspired/biomimetic functionalities into the development and production of synthetic materials across different size scales. They are familiar with the current possibilities but also the limits and restrictions of modern biomimetics are able to develop solutions using the current specialized literature.
Content	- Bioinspired materials: traditional biomimetics from macro- to microscale - Structural and functional applications - Medical applications - Molecular-based biomimetics - Biomineralization-inspired materials and systems - Autonomous functional materials and systems - Life-inspired systems - Engineered bio-hybrid living materials - Design methods for architectured materials
Teaching Methods	2 lecture hours per week (2 SWS)
Course / Teaching and Learning Methods	The educational content is generally disseminated using slides (e.g., PowerPoint) or board drawings as part of the lecture. The content is related to practice and explained through examples taken from the current specialized literature. Open questions are discussed and answered in the group.
Examination Type(s)	Module final examination as a written exam (60 minutes)
Recommendations for Participation	Successful participation in the modules: - Biology and Basic Bionics

	- Advanced Biology and Bionics After consultation with the lecturer, the basic knowledge in selected fields can be acquired during independent studying on a case-by-case basis.
Prerequisite for Being Awarded ECTS Credits	Passed module final examination (see examination types)
Application of the Module (in Other Degree Programs)	None
Bibliography / Literature	Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course(s) or during the lecture as they relate to the content and tasks. A selection is shown below: - M. A. Meyers, P.-Y. Chen, Biological Materials Science, Cambridge University Press, 2014. - P. Fratzl et al., Materials Design Inspired by Nature: Function Through Inner Architecture, RSC Publishing, 2013. - Y. Estrin et al., Architectured Materials in Nature and Engineering: Archimats, Springer Series in Materials Science Book 282, Springer, 2019.

Module Description	**Sustainable Polymeric Materials and Nanotechnology**
Module Abbreviation	**SME-M-2-2.02**
Module Coordinator	**Sabine Fuchs**

ECTS Credits	5	**Total Workload**	150 hours
Weekly Contact Hrs (SWS)	4	**Attendance Hours**	80 hours
Language	English	**Self-Study Time**	70 hours

Semester / Frequency of the Course Offering / Duration	2nd study semester / Winter semester / 1 semester

Objectives	Students learn the properties and handling of recyclable and/or bio-based/biodegradable plastics with the aim of nano-functionalization. To this end, they compile the suitable parameters for the production, characterization, and functionality checking of these materials. Students select suitable methods for processing and characterizing plastics and apply them. They evaluate processing and analysis data and interpret the results from tests conducted on workpieces on the basis of sustainable functional plastics. Students are able to evaluate nano-sized material systems in terms of their functionality and sustainability. They are able to select suitable materials to produce nanoparticles for particular applications. Moreover, they are able to select suitable characterization methods and analyze their results.
Content	Sustainable Polymeric Materials: - Bio/Ecoplastics: (a) PLA, PBS, PE, and PA plastics, (b) biodegradable and compostable plastics and/or additives, (c) oxo-biodegradable plastic formulations - Recycling and recycled plastics: PP, PE, PS, PA, PC-ABS, ABS, and PC - Functionality of nanoparticles in recycled, bio-based, and/or biodegradable plastics Nanotechnology: - Nanomaterials and nanostructured materials: structure, function, and applications - Production of nanoparticles: (a) top-down, (b) bottom-up - Characterization of nanoparticles: (a) by light scattering, (b) imaging, (c) spectroscopically - Risk assessment and sustainability assessment

	Laboratory course “Sustainable Polymeric Materials and Nanotechnology”: - Synthesis / production of a nanoparticulate material system (e.g., TiO_2 or SiO_2 nanoparticles) - Analysis and assessment of the nanoparticles produced - Production of plastic components with nanoparticles in the polymer matrix - Characterization of selected functional properties of the component
Teaching Methods	2 lecture hours per week, 1 practice course hour per week, 1 lab hour per week (4 SWS) Part of the courses may be held in the form of a subject-related field trip.
Course / Teaching and Learning Methods	The educational content is generally disseminated using slides (e.g., PowerPoint) or board drawings as part of the lectures. The content is related to practice and explained using examples where relevant. Students gain a deeper understanding of the lecture content during the practice courses via suitable practice problems. This gives students the opportunity to present the solutions to the practice problems on the board under the moderation of a lecturer. The laboratory course serves to supplement and deepen the knowledge acquired as part of the lecture and practice course. To prepare for the laboratory course, students may have to learn about experiments and experiment setups through independent studying using the documents provided. During the laboratory course, students conduct experiments under direction and supervision and prepare their own experiment reports at the end of the course, where appropriate.
Examination Type(s)	Module final examination as a written exam (90 minutes). Successful participation in the laboratory course “Sustainable Polymeric Materials and Nanotechnology” is documented via certificates obtained for the experiment days and via the experiment protocols. Weighting of each partial performance for the final grade: 70 : 30 (lecture/practice course : laboratory course).
Recommendations for Participation	- Knowledge of organic chemistry: understanding the structure, nomenclature, and reactivity of organic molecules including the associated reaction mechanisms - Knowledge of Macromolecular Chemistry and Polymer Chemistry: understanding the structure, nomenclature, and reactivity of macromolecules/polymers including the associated reaction mechanisms

	- Knowledge of plastics technology: properties of plastics, processing technologies, and test methods - Knowledge about the physics of nanosubstances and materials - Knowledge about the micro-/nanocharacterization of materials After consultation with the lecturer, the basic knowledge in selected fields can be acquired during independent studying on a case-by-case basis.
Prerequisite for Being Awarded ECTS Credits	Passed module final examination (see examination types)
Application of the Module (in Other Degree Programs)	None
Bibliography / Literature	Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course(s) or during the lecture as they relate to the content and tasks.

Module Description	**Research Seminar**
Module Abbreviation	**SME-M-2-2.03**
Module Coordinator	**Helge Fabritius**

ECTS Credits	5	**Total Workload**	150 hours
Weekly Contact Hrs (SWS)	3	**Attendance Hours**	45 hours
Language	English	**Self-Study Time**	105 hours

Semester / Frequency of the Course Offering / Duration	2nd study semester / Winter semester / 1 semester

Objectives	Students are familiar with the scientific method used in the research of a subject area. They can appropriately formulate issues of the current state of research and present and discuss their research findings both verbally and in writing in accordance with the recognized standards of the field.
Content	Interdisciplinary content from the research areas of - Biological and bio-inspired materials - Functional polymers and polymer additives - Sustainable (bio-)polymers - Optical materials - Materials for electrical engineering - Nanotechnology - Materials Physics is addressed and soldified using examples from current research projects.
Teaching Methods	1 lecture hour per week, 2 seminar hours per week (3 SWS)
Course / Teaching and Learning Methods	The educational content is generally discussed together with the students using slides (e.g., PowerPoint) or board drawings as part of the course. The content is related to practice and explained using examples where relevant. During the seminar part of the course, the lecture content is expanded by relevant current aspects and examples. This gives students the opportunity to present the content they have worked on under the moderation of a lecturer.
Examination Type(s)	Seminar paper during the semester (approx. 8-10 pages) and a presentation (min. 10 minutes and max. 15 minutes) Weighting of each partial performance for the final grade: 50 : 50
Recommendations for Participation	Successful participation in the modules: - Advanced Biology and Bionics

	- Advanced Organic and Polymer Chemistry - Materials of Electrical Engineering - Advanced Physics of Materials - Materials Characterization (from the credit alignment semester) After consultation with the lecturer, knowledge in selected fields can be acquired during independent studying on a case-by-case basis.
Prerequisite for Being Awarded ECTS Credits	Passed module final examination (see examination types)
Application of the Module (in Other Degree Programs)	None
Bibliography / Literature	Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course(s) or during the lecture as they relate to the content and tasks.

Module Description	**Research Lab Course**
Module Abbreviation	**SME-M-2-2.05**
Module Coordinator	**Sabine Fuchs**

ECTS Credits	10	**Total Workload**	300 hours
Weekly Contact Hrs (SWS)	6	**Attendance Hours**	90 hours
Language	English	**Self-Study Time**	210 hours

Semester / Frequency of the Course Offering / Duration	2nd study semester / Winter semester / 1 semester

Objectives	Students are familiar with the scientific method in the research of the working group's subject. They are able to appropriately deal with issues of the current state of research and present and discuss their research findings both verbally and in writing in accordance with the recognized standards of the field. They will join a research group that generally consists of employees with extremely different scientific and cultural backgrounds. They are able to work constructively in a multidisciplinary team while taking aspects of gender and diversity into account.
Content	Under the supervision of members of the working group, students work on a current project from among the research topics of the supervising working group. This includes research on the scientific background, practical realization of the project, the presentation and critical discussion of the results in talks with the supervisors (normally in English), and written documentation of the project.
Teaching Methods	6 laboratory course hours per week (6 SWS)
Course / Teaching and Learning Methods	The laboratory course serves to supplement and deepen the knowledge acquired as part of the master's study program. To prepare for the laboratory course, students may have to learn about experiments and experiment setups through independent studying using the documents provided. Students conduct supervised and guided experiments during the laboratory course. They also produce their own experiment report (laboratory journal) during the laboratory course and a final test report at the end of the laboratory course. They document their research data in accordance with the recognized regulations of the respective subject areas as well as the Guidelines for Safeguarding Good Research Practice of the DFG.

Examination Type(s)	Experiment report (laboratory journal) during the laboratory course and a final test report for the laboratory course / term paper (approx. 15-20 pages).
Recommendations for Participation	Successful participation in the modules: - Advanced Biology and Bionics - Advanced Organic and Polymer Chemistry - Materials of Electrical Engineering - Advanced Physics of Materials - Materials Characterization (from the credit alignment semester) After consultation with the lecturer, knowledge in selected fields can be acquired during independent studying on a case-by-case basis.
Prerequisite for Being Awarded ECTS Credits	Passed module final examination (see examination types)
Application of the Module (in Other Degree Programs)	None
Bibliography / Literature	Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course or during the lab as they relate to the content and tasks.

Module Description	**Scientific and Business Communication**
Module Abbreviation	**SME-M-2-2.04**
Module Coordinator	**Birte Horn**

ECTS Credits	5	**Total Workload**	150 hours
Weekly Contact Hrs (SWS)	2	**Attendance Hours**	30 hours
Language	English	**Self-Study Time**	120 hours

Semester / Frequency of the Course Offering / Duration	2nd study semester / Winter semester / 1 semester

Objectives	Students develop the skills to effectively communicate during their studies and for their professional work. By using scientific communication methods in a targeted manner, they achieve an understanding of scientific and technical texts in English, successfully grasping and interpreting specialist terminology. With regard to oral and written communication, the students display analytical and synchronic skills. This includes clear and precise communication of ideas and concepts while simultaneously considering the needs of their audience. The application of the knowledge they gained in scientific communication are manifested in the independent drafting of scientific and technical texts in English in which they analyze and assess information. In addition, the students integrate skills from the area of business communications. This is shown in the development of sophisticated business communication, where they plan and conduct projects not only while considering scientific standards and legal aspects but also with a deep understanding of business requirements. Their understanding of the principles of scientific work enable students to both realize projects in a structured manner and develop and implement business communication strategies. In this, they place special emphasis on following scientific standards, legal aspects, and specific requirements of the business environment. Moreover, the students show the ability to apply research methods and present results in accordance with the requirements of both scientific standards and business necessities.
Content	- Preparing and writing scientific and technical texts and articles - Scientific conversation and communication - Business conversation and communication

	- Citations, intellectual property law, and plagiarism - Reflecting on and preparing follow-ups of discussions - Preparation and realization of presentation documents with a focus on the short, succinct presentations that are useful to their day-to-day work - Training their linguistic verbal and written skills in the area GER B2-C1 - Practice exercises in the area of scientific writing in English and drafting academic texts as preparation for a Master's thesis in English
Teaching Methods	2 seminar hours per week (2 SWS)
Course / Teaching and Learning Methods	Seminar: lectures, case studies, individual and group work, presentations, reflection and feedback discussions that are prepared by the students as part of self study using targeted work packages. As part of the course, a subject-related field trip may be organized.
Examination Type(s)	Seminar paper during the semester (approx. 8-10 pages, approx. 80% of the overall grade) and a presentation (approx. 10 minutes, approx. 20% of the overall grade). The module can include short projects that are thematically and didactically integrated into the course. Bonus points can be awarded. The exact modalities will be explained on the second day of class at the latest.
Recommendations for Participation	Basic knowledge of the areas "Technical English" and "English Communication" is recommended (please refer to the courses of the same name in the module "English for Engineers" in, e.g., the degree program "Materials Science and Bionics").
Prerequisite for Being Awarded ECTS Credits	Passed module final examination (see examination types)
Application of the Module (in Other Degree Programs)	None
Bibliography / Literature	Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the course(s) or during the lecture as they relate to the content and tasks. A selection is shown below: - N. Brieger, A. Pohl, Technical English Vocabulary and Grammar, Langenscheidt, Munich, 2004. - G. Butzphal, J. Maier-Fairclough, Career-Express – Business English: B2 course book with audio Cd's and phrasebook, Cornelsen, Berlin, 2010. - E. Chastain, How to write a research paper, Barnes & Nobles, New York, 2006. - J. Comfort, Effective Presentations, Oxford University Press, 2009.

	- M. Grussendorf, English for presentations, Cornelsen, Berlin, 2010. - E. Ledden, The presentation book: how to create it, shape it and deliver it!, Pearson, Harlow [i.a.], 2013. - T. Skern, Writing Scientific English, UTB, Vienna, 2009.

Module Description	**Master’s thesis including master's seminar**
Module Abbreviation	**SME-M-2-3.01**
Module Coordinator	**Jörg Wenz**

ECTS Credits	30	**Total Workload**	900 hours
Weekly Contact Hrs (SWS)	0	**Attendance Hours**	450 hours
Language	English	**Self-Study Time**	450 hours

Semester / Frequency of the Course Offering / Duration	3rd study semester / Every summer semester / 1 semester

Objectives	Students are able to independently deal with a concrete question or a specific problem from a scientific and technical area of their specialized field using scientific methods to link the knowledge they have gained from their degree program and apply it to concrete problems. Students are able to structure, plan, and deal with their solutions in terms of time and content use scientific methods in order to find solutions to such a concrete question and implement them where appropriate. Furthermore, students are able to structure the results of their Master’s thesis in writing such that the relevant aspects of the solution are presented in a clearly structured form. Moreover, students are capable of presenting the project documentation of a larger project, such as a Master’s thesis, quickly yet comprehensively. They are able to defend the results of a scientific project from critical questions and discus possible alternatives, uncertainties, and consequences of the Master’s thesis in the scientific community.
Content	A concrete and current question from the practical environment of a company or a research project is desirable but not absolutely necessary. The content of the work should be designed such that it requires the integration of content from several modules from the degree program and includes both subject-specific technical and interdisciplinary components.
Teaching Methods	Master’s thesis (25 ECTS) and master's seminar (5 ECTS). Independent work, possibly under the guidance of a research assistant and accompanying technical discussion with the supervising teaching staff.

Course / Teaching and Learning Methods	Independent processing of the task that is accompanied by a defined supervisor from the professors for technical and organizational guidance. For the concrete form of the Master's thesis, the aim is to carry it out in an external company in cooperation with the HSHL or in a research project being carried out at the HSHL in the various research groups.
Examination Type(s)	The Master's thesis is graded. Both the written submission (Master's thesis) and oral performance (master's seminar) are evaluated. The oral performance must be rated at least "sufficient". Otherwise the module will receive the grade "not passed". Scope of the written documentation: Approx. 70 pages of text depending on the task type (plus any programming text or other annexes such as report data, graphical measurement results, complex calculations, etc.). Scope of the oral test: 15-minute presentation plus a colloquium discussion.
Recommendations for Participation	The correct application of scientific tools (including research and the selection of suitable specialized literature or the correct use of citation rules) is considered an essential prerequisite for the success of the Master's thesis. Therefore, all students are strongly recommended to become especially acquainted with the course offering of the Center for Knowledge Management (ZFW). There, you are offered the opportunity to consolidate and expand the abilities under the rubric "academic work" already developed as part of your Bachelor's thesis in a variety of ways. Moreover, it is recommended to successfully complete as many modules as possible in the first two semesters.
Prerequisite for Being Awarded ECTS Credits	Passed module final examination (see examination types)
Application of the Module (in Other Degree Programs)	Is comparably offered in all master's programs.
Bibliography / Literature	Subject-specific, independent research of literature with support from the supervisor. Officially available HSHL documents for information about the content and organization of the Master's thesis including examination requirements. Recommendations for literature, sources, media, software, etc., will be provided at the beginning of the Master's thesis by the supervising instructor as they relate to the content and tasks. A selection is shown below:

	- T. Skirn, Writing Scientific English: A Workbook, 3rd ed., UTB, 2019. - Guidelines for Scientific Writing, Technology Marketing, ETH Zurich, https://ethz.ch/content/dam/ethz/special-interest/mtec/technology-marketing/Teaching/TechMkt_Guidelines%20for%20Scientific%20Writing_27.02.2018.pdf (assessed 6/19/2024). - Y. N. Bui, How to Write a Master's Thesis, 3rd ed., SAGE Publications, 2019. - W. Strunk, Jr., E. B. White, The Elements of Style, 4th ed., Allyn & Bacon, Needham Heights/United States, 2000.