
Module Catalogue

Master Materials Science and Engineering

Faculty of Mathematics, Natural Sciences, and Materials Engineering

Examination regulations of 17.02.2022

You can see the other use cases of the modules in Digicampus.

Important additional information due to the corona pandemic:

Please note that due to the ongoing development of the coronavirus pandemic, the details relating to the format of examinations for each module within the module catalogue may not be up to date. The examination formats for each module will be clarified and determined during the course of the semester.

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* = At least one course for this module is offered in the current semester

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* = At least one course for this module is offered in the current semester

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* = At least one course for this module is offered in the current semester

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* = At least one course for this module is offered in the current semester

Module MRM-0143: Materials Engineering <i>Materials Engineering</i>		6 ECTS/LP
Version 1.0.0 Person responsible for module: Prof. Dr.-Ing. Dietmar Koch		
Contents: <ul style="list-style-type: none"> • Introduction: basics of materials science, goals of materials science for engineering • Chemical bondings, amorphous and crystalline structures • Material classes and their principle properties • Metals • Polymers • Ceramics and glasses • Natural materials • Reinforced materials • Resource management and sustainability of materials • Processing and design of materials for engineering application 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students know the basic terms and concepts of materials for engineering application. • The students have the competence to explain material properties and describe their specific functionality. • The students are able to choose the right materials according to application relevant conditions. • The students are able to design components considering principle properties of materials. • The students acquire scientific skills to search for scientific literature and to evaluate scientific content. 		
Workload: Total: 180 h 120 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Basic knowledge of material science.		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: any	
Parts of the Module		
Part of the Module: Materials Engineering Mode of Instruction: lecture Language: English Contact Hours: 3		
Learning Outcome: see description of module		
Contents: see description of module		
Literature: <ul style="list-style-type: none"> • W.D. Callister, Materials Science and Engineering (Wiley) • D. Askeland, P. Phule, The Science and Engineering of Materials • M.F. Ashby, D.R.H. Jones, Engineering Materials (Cambridge Univ. Press) • G. Gottstein, Physikalische Grundlagen der Materialkunde (Springer) 		
Assigned Courses:		

Materials Engineering (lecture + exercise)
Examination Materials Engineering written exam / length of examination: 90 minutes
Parts of the Module
Part of the Module: Materials Engineering Mode of Instruction: exercise course Language: English Contact Hours: 1
Learning Outcome: see description of module
Contents: see description of module
Assigned Courses: Materials Engineering (lecture + exercise)

Module MRM-0144: Materials Simulation <i>Materials Simulation</i>		6 ECTS/LP
Version 1.0.0 Person responsible for module: Prof. Dr.-Ing. Christian Weißenfels Prof. Dr. Liviu Chioncel		
Contents: The lecture contains: <ul style="list-style-type: none"> • Tensor calculus • Kinematics of continua • Stresses • Balance laws • Elasticity • Plasticity • Viscoelasticity 		
Learning Outcomes / Competences: Students learn the mathematical equations to describe the behavior of 3-dimensional, deformable bodies under loadings. The equations are composed of conservation laws, kinematical equations and material models. In the course of the lecture, models are introduced to describe elastic, viscoelastic and plastic material behavior.		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 120 h studying of course content using provided materials (self-study)		
Conditions: none, Engineering Mechanics is recommended		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester:	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: any	
Parts of the Module		
Part of the Module: Exercise to Materials Simulation Mode of Instruction: exercise course Language: English Contact Hours: 2		
Learning Outcome: See description of module.		
Contents: See description of module.		
Assigned Courses: Exercise to Materials Simulation (exercise course)		
Parts of the Module		
Part of the Module: Material Modeling Mode of Instruction: lecture Language: English Contact Hours: 2		

Contents:

See description of module.

Literature:

- G. Holzapfel: Nonlinear Solid Mechanics, John Wiley & Sons.
- J. Lemaitre, J.L. Chaboche: Mechanics of Solid Materials, Cambridge Univ. Press.
- P. Haupt: Continuum Mechanics and Theory of Materials, Springer.

Assigned Courses:

Materials Simulation (lecture)

Examination

Materials Simulation

written exam / length of examination: 90 minutes

Module PHM-0144: Materials Physics <i>Materials Physics</i>		6 ECTS/LP
Version 1.1.0 (since WS15/16) Person responsible for module: apl. Prof. Dr. Helmut Karl		
Contents: <ul style="list-style-type: none"> • Electrons in solids • Phonons • Properties of metals, semiconductors and insulators • Application in optical, electronic, and optoelectronic devices • Dielectric solids, optical properties 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students know the basic terms and concepts of solid state physics like the free electron gas, electronic band structure, charge carrier statistics, phonons, doping and optical properties, • are capable to apply derived approximations as the effective mass or the electron-hole concept to describe basic characteristics of semiconductor materials, • have the competence to apply these concepts for the description of electric, electro-optic and thermal properties of solids and to describe their functionalities, • understand size effects on material physical properties. • Integrated acquirement of soft skills: Working with specialist literature, literature search and interdisciplinary thinking. 		
Remarks: compulsory module		
Workload: Total: 180 h 120 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance)		
Conditions: basic knowledge of solid state physics		
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Materials Physics Mode of Instruction: lecture Language: English Contact Hours: 3		
Learning Outcome: see module description		

Contents:

- Electrons in solids: Free electron gas, band structure, effective mass
- Lattice dynamics: Phonons, phonon dispersion, acoustic and optical phonons
- Properties of metals: Electrical conductivity, Fermi surfaces, thermal properties
- Properties of semiconductors: Pure, intrinsic semiconductors, equilibrium conditions, doping
- Properties of dielectric materials: Propagation of electromagnetic waves, frequency dependent optical properties, polarization effects.
- Application in devices: Heterostructures, Schottky contact, pn-junction, solar cell, light emission and technological aspects

Literature:

- Hummel R. E. : Electronic Properties of Materials Springer 2001 (UP1000 H925)
- Burns G.: Solid State Physics Academic Press 1990 (UP1000 B967)
- Ashcroft N. W. , Mermin N.D. : Solid State Physics (UP1000 A 824)
- Kittel C. : Introduction to Solid State Physics (UP1000 K 62)

Assigned Courses:

Materials Physics (lecture)

Part of the Module: Materials Physics (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Learning Outcome:

see module description

Assigned Courses:

Materials Physics (Tutorial) (exercise course)

Examination

Materials Physics

written exam / length of examination: 90 minutes

Examination Prerequisites:

Materials Physics

Module MRM-0025: Fiber Reinforced Polymers for Engineers <i>Faserverbundkunststoffe - Produktion und Anwendung</i>		6 ECTS/LP
Version 1.0.0 (since WS15/16) Person responsible for module: Prof. Dr.-Ing. Michael Kupke		
Learning Outcomes / Competences: Die Studierenden - kennen die Vor- und Nachteile von Faserverbundwerkstoffen in Herstellung und Anwendung - haben ein Verständnis über faserverbundgerechte Bauweisen - kennen das Prinzip der Bauweisenbewertung für das Produkt		
Remarks: Ansprechpartnerin: Prof. Dr.-Ing. Michael Kupke, Tobias Karrasch (tobias.karrasch@mrm.uni-augsburg.de)		
Workload: Total: 180 h		
Conditions: none		Credit Requirements: Schriftliche Prüfung
Frequency: each semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 2	Repeat Exams Permitted: any	
Parts of the Module		
Part of the Module: Faserverbundkunststoffe für Ingenieure Mode of Instruction: lecture Lecturers: Prof. Dr.-Ing. Michael Kupke Language: German Contact Hours: 2		
Contents: 1. Grundlagen 2. Herstellung 3. Produktion 4. Anwendung		
Lehr-/Lernmethoden: Tafelanschrift und Beamerpräsentation		
Literature: wird in der Vorlesung bekannt gegeben		
Assigned Courses: Faserverbundkunststoffe – Produktion und Anwendung (Faserverbundkunststoffe für Ing.) (lecture)		
Examination Faserverbundkunststoffe für Ingenieure written exam, Schriftliche Prüfung		

Module MRM-0126: Ceramic Matrix Composites <i>Keramische Faserverbundwerkstoffe</i>		6 ECTS/LP
Version 3.0.0 (since WS21/22) Person responsible for module: Prof. Dr.-Ing. Dietmar Koch		
Contents: <ul style="list-style-type: none"> • Introduction in ceramic matrix composites • Basics of processing of technical ceramics • Processing chain of ceramic matrix composites (CMC) from raw materials to product • Processing and properties of ceramic fibers • Principal mechanisms of reinforcement in CMC • Properties of CMC • Application of CMC 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students know the basic concepts of mechanical behavior of ceramic matrix composites • The students have the competence to explain processing of ceramic fibers and ceramic matrix composites and describe their specific properties • The students know the Weibull statistics which describe the fiber strength distribution • The students know how to describe mechanical interactions between fiber and matrix • The students get the knowledge of application of ceramic matrix composites and are able to choose the according material for specific application. • The students acquire scientific skills to search for scientific literature and to evaluate scientific content 		
Workload: Total: 180 h 120 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Recommended: basic knowledge of materials		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Keramische Faserverbundwerkstoffe		
Mode of Instruction: lecture		
Language: English		
Contact Hours: 3		
Learning Outcome: see description of module		
Contents: see description of module		

<p>Literature:</p> <ul style="list-style-type: none">• N.P. Bansal, J. Lamon, Ceramic Matrix Composites: Materials, Modeling and Technology. John Wiley & Sons, Inc., 2015.• W. Krenkel, Ceramic Matrix Composites. Wiley-VCH Verlag GmbH & Co. KGaA, 2008.• K. K. Chawla, Composite Materials 3rd ed., Springer, 2012• T. Ohji, M. Singh, Engineered Ceramics: Current Status and Future Prospects, ISBN: 978-1-119-10042-3, 2015
<p>Assigned Courses:</p> <p>Keramische Faserverbundwerkstoffe (lecture)</p>
<p>Examination</p> <p>Keramische Faserverbundwerkstoffe written exam, written exam / length of examination: 60 minutes</p>
<p>Parts of the Module</p>
<p>Part of the Module: Übung Keramische Faserverbundwerkstoffe</p> <p>Mode of Instruction: exercise course</p> <p>Language: English</p> <p>Contact Hours: 1</p>
<p>Learning Outcome: see description of module</p>
<p>Contents: see description of module</p>
<p>Literature: see description of module</p>
<p>Assigned Courses:</p> <p>Keramische Faserverbundwerkstoffe (lecture)</p>

Module MRM-0128: Bioinspired Composites <i>Bioinspired Composites</i>		6 ECTS/LP
Version 2.0.0 (since WS20/21) Person responsible for module: Prof. Dr.-Ing. Dietmar Koch		
Contents: <ul style="list-style-type: none"> • Introduction in bionics and bioinspiration • Basics of bionic principles • Fundamental approaches to develop technical components based on bioinspired ideas • Topology optimization • Bioinspired ceramic and polymer based components • Natural fiber based bioinspired materials • Application of bioinspired materials 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students know the basic principles of bionics and bioinspiration • The students know the bionically motivated development of technical components • The students have the competence to explain topology optimization • The students understand general principles bioinspired composites • The students get the knowledge about manufacturing, properties and application of natural fiber based composites • The students acquire scientific skills to search for scientific literature and to evaluate scientific content 		
Workload: Total: 180 h 120 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance)		
Conditions: basic knowledge of material science		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Bioinspired Composites Mode of Instruction: lecture Lecturers: Prof. Dr.-Ing. Dietmar Koch Language: English / German Frequency: each summer semester Contact Hours: 3		
Contents: see description of module		

Literature:

- B. Arnold, Werkstofftechnik für Wirtschaftsingenieure. 1. Auflage, Springer Verlag (2013)
- W. Bobeth (Ed.), Textile Faserstoffe - Beschaffenheit und Eigenschaft, Springer-Verlag (1993)
- W. Nachtigal, K. G. Blüchel, Das große Buch der Bionik – Neue Technologien nach dem Vorbild der Natur. 2. Auflage, Deutsche Verlags-Anstalt (2001)
- C. Hamm (Ed.), Evolution of Light Weight Structures - Analyses and Technical Applications, Springer-Verlag (2015)
- J. Müssig (Ed.), C. V. Stevens (Series Ed.), Industrial Applications of Natural Fibres: Structure, Properties and Technical Applications, Wiley Series in Renewable Resources (2010)

Examination

Bioinspired Composites

written exam, written exam / length of examination: 60 minutes

Parts of the Module

Part of the Module: Übung Bioinspired Composites

Mode of Instruction: exercise course

Language: German

Frequency: each summer semester

Contact Hours: 1

Learning Outcome:

see description of module

Contents:

see description of module

Literature:

see description of module

Module MRM-0136: Mechanical Characterization of Materials <i>Mechanical Characterization of Materials</i>		6 ECTS/LP
Version 1.1.0 (since SoSe21) Person responsible for module: Prof. Dr. Markus Sause		
Contents: The following topics are presented: <ul style="list-style-type: none"> • Introduction to material characterization • Linear material behaviour • Non-linear material behaviour • Material failure • Measurement technologies • Tensile testing • Compression testing • Shear testing • Other static testing concepts • Fracture mechanics • Assembly testing • Surface mechanics • Creep testing • Fatigue testing • High-Velocity testing • Component testing 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • Acquire knowledge in the field of materials testing and evaluation of materials. • Are introduced to important concepts in measurement techniques, and material models. • Are able to independently acquire further knowledge of the scientific topic using various forms of information. 		
Workload: Total: 180 h 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 60 h lecture and exercise course (attendance)		
Conditions: None		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Mechanical Characterization of Materials Mode of Instruction: lecture Language: English Contact Hours: 3		

Literature:

- Issler, L., & Häfele, H. R. P. (2003). Festigkeitslehre — Grundlagen. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-540-73485-7>
- Dowling, N. E. (2019). Mechanical Behavior of Materials (4th ed.). Pearson.
- Gross, D., & Seelig, T. (2011). Fracture Mechanics. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-642-19240-1>
- J. Schijve. (2008). Fatigue of Structures and Materials (2nd Edition). Springer Science & Business Media.
- Sadd, M. H. (2018). Continuum Mechanics Modeling of Material Behavior. In Continuum Mechanics Modeling of Material Behavior. Elsevier. <https://doi.org/10.1016/C2016-0-01495-X>

Examination

Mechanical Characterization of Materials

written exam, written exam / length of examination: 90 minutes

Parts of the Module

Part of the Module: Mechanical Characterization of Materials (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Module MRM-0142: Complex 3D Structures and Components from 2D Materials <i>Complex 3D Structures and Components from 2D Materials</i>	6 ECTS/LP
Version 1.0.0 Person responsible for module: Prof. Dr.-Ing. Suelen Barg	
Contents: Introduction: <ul style="list-style-type: none"> • Complex Materials in Nature • Motivations in assembling 2D Materials in 3D with an overview of their demands for future technological applications (from energy to aerospace) Nano and 2D Materials: <ul style="list-style-type: none"> • Introduction to nano and 2D Materials • Scaling laws and the evolution of properties with size • Graphene structure, properties, and characterization • 2D Transition Metal Carbides (MXenes) • 2D Materials synthesis routes: top-down and bottom-up approaches From 2D to 3D: <ul style="list-style-type: none"> • Motivations, Challenges, and opportunities • Colloidal processing routes with 2D Materials: Principles of wet processing • Self-assembly, templating, and additive manufacturing (AM) routes • Extrusion-based AM with 2D Materials • Functionalities and Applications • Aerogel supports for functional composite development • 3D architectures for energy storage 	
Learning Outcomes / Competences: By completing this unit, the students should be able to: Knowledge and understanding: <ul style="list-style-type: none"> • Define the classes of nanomaterials depending on their dimensionality. • Identify the different families of 2D materials beyond graphene, including transition metal dichalcogenides (TMDs), carbides and/or nitrides (MXenes). • Summarize top-down and bottom-up synthesis strategies towards 2D materials. • Select appropriate syntheses routes for a given application based on property requirements and cost efficiency of the approach. • Explain the basic principles, advantages and disadvantages of innovative colloidal processing routes applied to 2D materials-based 3D structures. Intellectual skills: <ul style="list-style-type: none"> • Solve problems involving the evolution of properties with size in nanomaterials by the application of simple spherical cluster approximation models. • Evaluate the effect of microstructure and composition to develop new materials properties and/or control device efficiency using real examples from the literature. Transferable and practical skills: <ul style="list-style-type: none"> • Evaluate English language scientific content in the specialist literature. • Apply analytical methods to solve problems. 	
Workload: Total: 180 h	

Conditions: materials science basic knowledge		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Complex 3D Structures and Components from 2D Materials		
Mode of Instruction: lecture		
Lecturers: Prof. Dr.-Ing. Suelen Barg		
Language: English		
Contact Hours: 4		
Learning Outcome: See description of the module		
Contents: See description of the module		
Literature: <ul style="list-style-type: none"> • Sulabha K Kulkarni, Nanotechnology: principles and Practice, 3rd Ed., 2015 (Springer-Verlag GmbH). • Leonard W. T. Ng, Guohua Hu, Richard C. T. Howe, Xiaoxi Zhu, Zongyin Yang, Printing of Graphene and Related 2D Materials, in: Technology, Formulation and Applications. 1st ed., 2019, (Springer-Verlag GmbH) • Research papers presented in class 		
Examination		
Complex 3D Structures and Components from 2D Materials written exam, written exam / length of examination: 1 hours		

Module PHM-0048: Physics and Technology of Semiconductor Devices <i>Physics and Technology of Semiconductor Devices</i>		6 ECTS/LP
Version 1.0.0 (since WS09/10) Person responsible for module: apl. Prof. Dr. Helmut Karl		
Contents: 1. Basic properties of semiconductors (electronic bandstructure, doping, carrier excitations and carrier transport) 2. Semiconductor diodes and transistors 3. Semiconductor technology		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • Basic knowledge of solid-state and semiconductor physics such as electronic bandstructure, doping, carrier excitations, and carrier transport. • Application of developed concepts (effective mass, quasi-Fermi levels) to describe the basic properties of semiconductors. • Application of these concepts to describe and understand the operation principles of semiconductor devices such as diodes and transistors • Knowledge of the technologically relevant methods and tools in semiconductor micro- and nanofabrication. • Integrated acquisition of soft skills: autonomous working with specialist literature in English, acquisition of presentation techniques, capacity for teamwork, ability to document experimental results, and interdisciplinary thinking and working. 		
Workload: Total: 180 h 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study) 60 h lecture and exercise course (attendance)		
Conditions: recommended prerequisites: basic knowledge in solid state physics, statistical physics and quantum mechanics.		
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Physics and Technology of Semiconductor Devices Mode of Instruction: lecture Language: English Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- Yu und Cardona: Fundamentals of Semiconductors (Springer)
- Sze: Physics of Semiconductor Devices (Wiley)
- Sze: Semiconductor Devices (Wiley)
- Madelung: Halbleiterphysik (Springer)
- Singh: Electronic and Optoelectronic Properties of Semiconductor Structures (Cambridge University Press)

Part of the Module: Physics and Technology of Semiconductor Devices (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Contents:

see module description

Examination

Physics and Technology of Semiconductor Devices

written exam / length of examination: 90 minutes

Examination Prerequisites:

Physics and Technology of Semiconductor Devices

Module PHM-0049: Nanostructures / Nanophysics <i>Nanostructures / Nanophysics</i>		6 ECTS/LP
Version 1.2.0 (since WS09/10) Person responsible for module: Prof. Dr. István Kézsmárki		
Contents: <ol style="list-style-type: none"> 1. Semiconductor quantum wells, wires and dots, low dimensional electron systems 2. Magnetotransport in low-dimensional systems, Quantum-Hall-Effect, Quantized conductance 3. Optical properties of nanostructures and their application in modern optoelectronic devices, Nanophotonics 4. Fabrication and detection techniques of nanostructures 5. Ferroic properties of nanostructures (Ferroelectricity, Magnetism, Multiferroicity) 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students gain basic knowledge of the fundamental concepts in modern nanoscale science. • The students have detailed knowledge of low-dimensional semiconductor structures and how these systems can be applied for novel functional devices for high-frequency electronics and optoelectronics • The students gain competence in selecting different fabrication and characterization approaches for specific nanostructures. • The students are able apply these concepts to tackle present problems in nanophysics. • The students acquire scientific skills to search for scientific literature and to evaluate scientific content. 		
Workload: Total: 180 h 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study)		
Conditions: recommended prerequisites: basic knowledge in solid-state physics and quantum mechanics.		
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Nanostructures / Nanophysics Mode of Instruction: lecture Language: English Contact Hours: 4		
Learning Outcome: see module description		
Contents: see module description		
Literature: <ul style="list-style-type: none"> • Yu und Cardona: Fundamentals of Semiconductors • Singh: Electronic and Optoelectronic Properties of Semiconductor Structures (Cambridge University Press) • Davies: The Physics of low-dimensional Semiconductors (Cambridge University Press) 		

Examination

Nanostructures / Nanophysics

oral exam / length of examination: 30 minutes

Examination Prerequisites:

Nanostructures / Nanophysics

Module PHM-0052: Solid State Spectroscopy with Synchrotron Radiation and Neutrons <i>Solid State Spectroscopy with Synchrotron Radiation and Neutrons</i>		6 ECTS/LP
Version 1.2.0 (since WS09/10) Person responsible for module: Prof. Dr. Christine Kuntscher		
Contents: <ol style="list-style-type: none"> 1. Electromagnetic radiation: description, generation, detection [5] 2. Spectral analysis of electromagnetic radiation: monochromators, spectrometer, interferometer [2] 3. Excitations in the solid state: Dielectric function [2] 4. Infrared spectroscopy 5. Ellipsometry 6. Photoemission spectroscopy 7. X-ray absorption spectroscopy 8. Neutrons: Sources, detectors 9. Neutron scattering 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basics of spectroscopy and important instrumentation and methods, • have acquired the skills of formulating a mathematical-physical ansatz in spectroscopy and can apply these in the field of solid state spectroscopy, • have the competence to deal with current problems in solid state spectroscopy autonomously, and are able to judge proper measurement methods for application. • Integrated acquirement of soft skills. 		
Workload: Total: 180 h 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: basic knowledge in solid-state physics		
Frequency: annually	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Solid State Spectroscopy with Synchrotron Radiation and Neutrons Mode of Instruction: lecture Language: English Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- H. Kuzmany, Solid State Spectroscopy (Springer)
- N. W. Ashcroft, N. D. Mermin, Solid State Physics (Holt, Rinehart and Winston)
- J. M. Hollas, Modern Spectroscopy

Part of the Module: Solid State Spectroscopy with Synchrotron Radiation and Neutrons (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Solid State Spectroscopy with Synchrotron Radiation and Neutrons

oral exam / length of examination: 30 minutes

Examination Prerequisites:

Solid State Spectroscopy with Synchrotron Radiation and Neutrons

Module PHM-0056: Ion-Solid Interaction <i>Ion-Solid Interaction</i>		6 ECTS/LP
Version 1.0.0 (since WS09/10) Person responsible for module: apl. Prof. Dr. Helmut Karl		
Contents: <ul style="list-style-type: none"> • Introduction (areas of scientific and technological application, principles) • Fundamentals of atomic collision processes (scattering, cross-sections, energy loss models, potentials in binary collision models) • Ion-induced modification of solids (integrated circuit fabrication with emphasis on ion induced phenomena, ion implantation, radiation damage, ion milling and etching (RIE), sputtering, erosion, deposition) • Transport phenomena • Analysis with ion beams 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the physical principles and the basic mechanisms of the interaction between particles and solid state bodies in the energy range of eV to MeV, • are able to choose adequate physical models for specific technological and scientific applications, and • have the competence to work extensively autonomous on problems concerning the interaction between ions and solid state bodies. • Integrated acquirement of soft skills. 		
Workload: Total: 180 h 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study) 80 h studying of course content through exercises / case studies (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Basic Courses in Physics I–IV, Solid State Physics, Nuclear Physics		
Frequency: annually	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Ion-Solid Interaction Mode of Instruction: lecture Language: English Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- R. Smith, Atomic and ion collisions in solids and at surfaces (Cambridge University Press, 1997)
- E. Rimini, Ion implantation: Basics to device fabrication (Kluwer, 1995)
- W. Eckstein: Computer Simulation of Ion-Solid Interactions (Springer, 1991)
- H. Ryssel, I. Ruge: Ionenimplantation (Teubner, 1978)
- Y. H. Ohtsuki: Charged Beam Interaction with Solids (Taylor & Francis, 1983)
- J. F. Ziegler (Hrsg.): The Stopping and Range of Ions in Solids (Pergamon)
- R. Behrisch (Hrsg.): Sputtering by Particle Bombardment (Springer)
- M. Nastasi, J. K. Hirvonen, J. W. Mayer: Ion-Solid Interactions: Fundamentals and Applications (Cambridge University Press, 1996)
- <http://www.SRIM.org>

Part of the Module: Ion-Solid Interaction (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Ion-Solid Interaction

written exam / length of examination: 90 minutes

Examination Prerequisites:

Ion-Solid Interaction

Module PHM-0057: Physics of Thin Films <i>Physics of Thin Films</i>		6 ECTS/LP
Version 1.6.0 (since WS09/10) Person responsible for module: PD Dr. German Hammerl		
Contents: <ul style="list-style-type: none"> Thin film growth: basics, thermodynamic considerations, surface kinetics, growth mechanisms Thin film growth techniques: vacuum technology, physical vapor deposition, chemical vapor deposition Analysis and characterization of thin films: in-sit methods, ex-situ methods, direct methods Properties and applications of thin films 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> know a broad spectrum of methods of thin film technology and material properties and applications of thin films, have the competence to deal with current problems in the field of thin film technology largely autonomous, are able to choose the right substrates and thin film materials for epitaxial thin film growth to achieve desired application conditions, acquire skills of combining the various technologies for growing thin layers with respect to their properties and applications, and acquire scientific soft skills to search for scientific literature, understand technical english, work with literature in the field of thin films, interpret experimental results. 		
Workload: Total: 180 h 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study)		
Conditions: none		
Frequency: each winter semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Physics of Thin Films Mode of Instruction: lecture Language: English Contact Hours: 4		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- H. Frey, G. Kienel, Dünnschichttechnologie (VDI Verlag, 1987)
- H. Lüth, Solid Surfaces, Interfaces and Thin Films (Springer Verlag, 2001)
- A. Wagendristel, Y. Wang, An Introduction to Physics and Technology of Thin Films (World Scientific Publishing, 1994)
- M. Ohring, The Materials Science of Thin Films (Academic Press, 1992)

Examination

Physics of Thin Films

written exam / length of examination: 90 minutes

Examination Prerequisites:

Physics of Thin Films

Module PHM-0058: Organic Semiconductors <i>Organic Semiconductors</i>		6 ECTS/LP
Version 1.3.0 (since WS09/10) Person responsible for module: Prof. Dr. Wolfgang Brütting		
Contents: Basic concepts and applications of organic semiconductors Introduction <ul style="list-style-type: none"> • Materials and preparation • Structural properties • Electronic structure • Optical and electrical properties Devices and Applications <ul style="list-style-type: none"> • Organic metals • Light-emitting diodes • Solar cells • Field-effect transistors 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic structural and electronic properties of organic semiconductors as well as the essential function of organic semiconductor devices, • have acquired skills for the classification of the materials taking into account their specific features in the functioning of components, • and have the competence to comprehend and attend to current problems in the field of organic electronics. • Integrated acquirement of soft skills: practicing technical English, working with English specialist literature, ability to interpret experimental results 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 40 h studying of course content through exercises / case studies (self-study) 40 h studying of course content using provided materials (self-study) 40 h studying of course content using literature (self-study)		
Conditions: It is strongly recommended to complete the module solid-state physics first. In addition, knowledge of molecular physics is desired.		
Frequency: annually	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module Part of the Module: Organic Semiconductors Mode of Instruction: lecture Language: English Contact Hours: 3		

Learning Outcome:

see module description

Contents:

see module description

Literature:

- M. Schwoerer, H. Ch. Wolf: Organic Molecular Solids (Wiley-VCH)
- W. Brütting: Physics of Organic Semiconductors (Wiley-VCH)
- A. Köhler, H. Bässler: Electronic Processes in Organic Semiconductors (Wiley-VCH)
- S.R. Forrest: Organic Electronics (Oxford Univ. Press)

Part of the Module: Organic Semiconductors (Tutorial)

Mode of Instruction: exercise course

Language: English

Frequency: every 3rd semester

Contact Hours: 1

Examination**Organic Semiconductors**

written exam / length of examination: 90 minutes

Examination Prerequisites:

Organic Semiconductors

Module PHM-0059: Magnetism <i>Magnetism</i>		6 ECTS/LP
Version 1.0.0 (since WS09/10) Person responsible for module: Dr. Hans-Albrecht Krug von Nidda		
Contents: <ul style="list-style-type: none"> • History, basics • Magnetic moments, classical and quantum phenomenology • Exchange interaction and mean-field theory • Magnetic anisotropy and magnetoelastic effects • Thermodynamics of magnetic systems and applications • Magnetic domains and domain walls • Magnetization processes and micro magnetic treatment • AC susceptibility and ESR • Spintransport / spintronics • Recent problems of magnetism 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic properties and phenomena of magnetic materials and the most important methods and concepts for their description, like mean-field theory, exchange interactions and micro magnetic models, • have the ability to classify different magnetic phenomena and to apply the corresponding models for their interpretation, and • have the competence independently to treat fundamental and typical topics and problems of magnetism. • Integrated acquirement of soft skills. 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study)		
Conditions: basics of solid-state physics and quantum mechanics		
Frequency: annually	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Magnetism		
Mode of Instruction: lecture		
Language: English		
Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- D. H. Martin, Magnetism in Solids (London Iliffe Books Ltd.)
- J. B. Goodenough, Magnetism and the Chemical Bond (Wiley)
- P. A. Cox, Transition Metal Oxides (Oxford University Press)
- C. Kittel, Solid State Physics (Wiley)
- D. C. Mattis, The Theory of Magnetism (Wiley)
- G. L. Squires, Thermal Neutron Scattering (Dover Publications Inc.)

Part of the Module: Magnetism (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Magnetism

written exam / length of examination: 90 minutes

Examination Prerequisites:

Magnetism

Module PHM-0060: Low Temperature Physics <i>Low Temperature Physics</i>		6 ECTS/LP
Version 1.1.0 (since WS09/10) Person responsible for module: Prof. Dr. Philipp Gegenwart		
Contents: <ul style="list-style-type: none"> • Introduction • Properties of matter at low temperatures • Cryoliquids and superfluidity • Cryogenic engineering • Thermometry • Quantum transport, criticality and entanglement in matter 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic properties of matter at low temperatures and the corresponding experimental techniques, • have acquired the theoretical knowledge to perform low-temperature measurements, • and know how to experimentally investigate current problems in low-temperature physics. 		
Workload: Total: 180 h 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 60 h lecture and exercise course (attendance) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: Physik IV - Solid-state physics		
Frequency: every 3rd semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Low Temperature Physics Mode of Instruction: lecture Language: English Contact Hours: 3		
Learning Outcome: see module description		

Contents:

- Introduction (temperature scale, history of low temperature physics)
- Properties of matter at low temperatures (specific heat, thermal expansion, electrical resistance, thermal conductivity)
- Cryoliquids and superfluidity (nitrogen, hydrogen, 4-He and 3-He: phase diagrams, superfluidity)
- Cryogenic engineering (liquefaction of gases, helium cryostats, dilution refrigerator, adiabatic demagnetization, further techniques)
- Thermometry (primary and secondary thermometers at different temperature regimes)
- Quantum Matter (quantum Transport, Quantum phase transitions, Quantum spin liquids)

Literature:

C. Enss, S. Hunklinger, Tieftemperaturphysik (Springer)
F. Pobell, Matter and Methods at Low Temperatures (Springer)

Part of the Module: Low Temperature Physics (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Low Temperature Physics

oral exam / length of examination: 30 minutes

Examination Prerequisites:

Low Temperature Physics

Module PHM-0066: Superconductivity <i>Superconductivity</i>		6 ECTS/LP
Version 1.0.0 (since WS11/12) Person responsible for module: Prof. Dr. Philipp Gegenwart		
Contents: <ul style="list-style-type: none"> • Introductory Remarks and Literature • History and Main Properties of the Superconducting State, an Overview • Phenomenological Thermodynamics and Electrodynamics of the SC • Ginzburg-Landau Theory • Microscopic Theories • Fundamental Experiments on the Nature of the Superconducting State • Josephson-Effects • High Temperature Superconductors • Application of Superconductivity 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • will get an introduction to superconductivity, • by a presentation of experimental results they will learn the fundamental properties of the superconducting state, • are informed about the most important technical applications of superconductivity. • Special attention will be drawn to the basic concepts of the main phenomeno-logical and microscopic theories of the superconducting state, to explain the experimental observations. • For self-studies a comprehensive list of further reading will be supplied. 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study)		
Conditions: <ul style="list-style-type: none"> • Physik IV – Solid-state physics • Theoretical physics I-III 		
Frequency: every 3rd semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Superconductivity Mode of Instruction: lecture Language: English Contact Hours: 4		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- W. Buckel, Supraleitung, 5. Auflage (VCH, Weinheim, 1994)
- W. Buckel und R. Kleiner, Supraleitung, 6. Auflage (WILEY-VCH, Weinheim, 2004)
- M. Tinkham, Introduction to Superconductivity, 2nd Edition (McGraw-Hill, Inc., New York, 1996, Reprint by Dover Publications Inc. Miniola , 2004)
- Weitere Literatur wird in der Vorlesung angegeben

Assigned Courses:

Superconductivity (lecture)

Examination

Superconductivity

oral exam / length of examination: 30 minutes

Examination Prerequisites:

Superconductivity

Module PHM-0068: Spintronics <i>Spintronics</i>		6 ECTS/LP
Version 1.6.0 (since SoSe14) Person responsible for module: PD Dr. German Hammerl		
Contents: <ul style="list-style-type: none"> • Basic micromagnetic interactions (exchange, anisotropy, DMI, stray fields, external fields) and where they come from • Emergence of spin textures such as domain walls and bubbles/skyrmions • Torques acting on the local magnetization (magnetic field torque, current in-plane spin-transfer torque, spin-Hall effect and spin-orbit torques) • Switching • Motion of spin textures, 1D model and Thiele equation • Magneto-resistance and Hall effects and their utility in electrical readout • Ultrafast effects • Device applications • Experimental techniques in the field of spintronics 		
Learning Outcomes / Competences: The students: The students: <ul style="list-style-type: none"> • know the fundamental interactions in magnetic materials, the basic spintronic effects, and the related device structures, • have the competence to deal with current problems in the field of spintronics largely autonomously, • are able to choose materials in order to achieve demanding properties in spintronic applications, • are able to design device components to achieve spin polarization, • acquire scientific skills in finding and understanding current literature dealing with spintronic devices and applications, identifying suitable materials and material combinations with respect to their applicability for spintronic devices. 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study)		
Conditions: none		
Frequency: each summer semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Spintronics Mode of Instruction: lecture Language: English Contact Hours: 3		

Learning Outcome:

see module description

Contents:

see module description

Literature:

- N. W. Ashcroft, N. D. Mermin, Solid State Physics, Cengage Learning (2011), ISBN: 81-315-0052-7
- C. Felser, G. H. Hechter, Spintronics - From Materials to Devices, Springer (2013), ISBN: 978-90-481-3831-9
- S. Bandyopadhyay, M. Cahay, Introduction to Spintronics, CRC Press (2008), ISBN: 978-0-9493-3133-6

Part of the Module: Spintronics (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Spintronics

written exam / length of examination: 90 minutes

Examination Prerequisites:

Spintronics

Module PHM-0069: Applied Magnetic Materials and Methods <i>Applied Magnetic Materials and Methods</i>		6 ECTS/LP
Version 1.1.0 (since WS14/15) Person responsible for module: Prof. Dr. Manfred Albrecht		
Contents: <ul style="list-style-type: none"> • Basics of magnetism • Ferrimagnets, permanent magnets • Magnetic nanoparticles • Superparamagnetism • Exchange bias effect • Magnetoresistance, sensors • Experimental methods (e.g. Mößbauer Spectroscopy, mu-SR) 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students know the basic terms and concepts of magnetism, • get a profound understanding of basic physical relations and their applications, • acquire the ability to describe qualitative observations, interpret quantitative measurements, and develop mathematical descriptions of physical effects of chosen magnetic material systems. • Integrated acquirement of soft skills: autonomous working with specialist literature in English, acquisition of presentation techniques, capacity for teamwork, ability to document experimental results, and interdisciplinary thinking and working. 		
Workload: Total: 180 h 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Basics in solid state physics		
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Applied Magnetic Materials and Methods		
Mode of Instruction: lecture		
Language: English		
Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		
Literature: Stephan Bundell, Magnetism in Condensed Matter, Oxford University Press, ISBN: 0-19-850591-4 (Pbk) J.M.C. Coey, Magnetism and Magnetic Materials, Cambridge University Press, ISBN: 978-0-521-81614-4 (hardback)		

Part of the Module: Applied Magnetic Materials and Methods (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Applied Magnetic Materials and Methods

oral exam / length of examination: 30 minutes

Examination Prerequisites:

Applied Magnetic Materials and Methods

Module PHM-0122: Non-Destructive Testing <i>Non-Destructive Testing</i>		6 ECTS/LP
Version 1.0.0 (since WS14/15) Person responsible for module: Prof. Dr. Markus Sause		
Contents: <ul style="list-style-type: none"> • Introduction to nondestructive testing methods • Visual inspection • Ultrasonic testing • Guided wave testing • Acoustic emission analysis • Thermography • Radiography • Eddy current testing • Specialized nondestructive methods 		
Learning Outcomes / Competences: The students <ul style="list-style-type: none"> • acquire knowledge in the field of nondestructive evaluation of materials, • are introduced to important concepts in nondestructive measurement techniques, • are able to independently acquire further knowledge of the scientific topic using various forms of information. • Integrated acquirement of soft skills 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: Basic knowledge on materials science, in particular composite materials		
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Non-Destructive Testing Mode of Instruction: lecture Language: English Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- Raj: Practical Non-destructive Testing
- Shull: Nondestructive Evaluation - Theory and Applications
- Krautkrämer: Ultrasonic testing of materials
- Grosse: Acoustic Emission Testing
- Rose: Ultrasonic waves in solid media
- Maldague: Nondestructive Evaluation of Materials by Infrared Thermography
- Herman: Fundamentals of Computerized Tomography

Further literature - actual scientific papers and reviews - will be announced at the beginning of the lecture.

Assigned Courses:

Non-Destructive Testing (lecture)

Part of the Module: Non-Destructive Testing (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Assigned Courses:

Non-Destructive Testing (Tutorial) (exercise course)

Examination

Non-Destructive Testing

written exam / length of examination: 90 minutes

Examination Prerequisites:

Non-Destructive Testing

Module PHM-0163: Fiber Reinforced Composites: Processing and Materials Properties <i>Fiber Reinforced Composites: Processing and Materials Properties</i>		6 ECTS/LP
Version 1.2.0 (since SoSe15) Person responsible for module: Dr. Judith Moosburger-Will		
Contents: <ul style="list-style-type: none"> • Production of fibers (e.g. glass, carbon, or ceramic fibers) • Physical and chemical properties of fibers and their precursor materials • Physical and chemical properties of commonly used polymeric and ceramic matrix materials • Semi-finished products • Composite production technologies • Application of fiber reinforced materials 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the physical and chemical properties of fibers, matrices, and fiber-reinforced materials. • know the basics of production technologies of fibers, polymeric, ceramic matrices, and fiber-reinforced materials. • know the application areas of composite materials. • have the competence to explain material properties of fibers, matrices, and composites. • have the competence to choose the right materials according to application relevant conditions. • are able to independently acquire further knowledge of the scientific topic using various forms of information. 		
Remarks: ELECTIVE COMPULSORY MODULE		
Workload: Total: 180 h 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Recommended: basic knowledge in materials science, basic lectures in organic chemistry		
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Fiber Reinforced Composites: Processing and Materials Properties Mode of Instruction: lecture Language: English Contact Hours: 3		

Literature:

- Morgan: Carbon fibers and their composites
- Ehrenstein: Polymeric materials
- Krenkel: Ceramic Matrix Composites
- Henning, Moeller: Handbuch Leichtbau
- Schürmann: Konstruieren mit Faser-Kunststoff-Verbunden
- Neitzel, Mitschang: Handbuch Verbundwerkstoffe

Further literature - actual scientific papers and reviews - will be announced at the beginning of the lecture.

Assigned Courses:

Fiber Reinforced Composites: Processing and Materials Properties (lecture)

Part of the Module: Fiber Reinforced Composites: Processing and Materials Properties (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Literature:

see lecture

Assigned Courses:

Fiber Reinforced Composites: Processing and Materials Properties (Tutorial) (exercise course)

Examination

Fiber Reinforced Composites: Processing and Materials Properties

written exam / length of examination: 90 minutes

Examination Prerequisites:

Fiber Reinforced Composites: Processing and Materials Properties

Module PHM-0168: Modern Metallic Materials <i>Modern Metallic Materials</i>		6 ECTS/LP
Version 1.0.0 (since SoSe15) Person responsible for module: Prof. Dr. Ferdinand Haider		
Contents: Introduction Review of physical metallurgy Steels: <ul style="list-style-type: none"> • principles • common alloying elements • martensitic transformations • dual phase steels • TRIP and TWIP steels • maraging steel • electrical steel • production and processing Aluminium alloys: <ul style="list-style-type: none"> • 2xxx • 6xxx • 7xxx • Processing – creep forming, hydroforming, spinforming Titanium alloys Magnesium alloys Superalloys Intermetallics, high entropy alloys		
Learning Outcomes / Competences: Students <ul style="list-style-type: none"> • learn about relevant classes of actual metallic alloys and their properties • acquire the skill to derive alloy properties from physical metallurgy principles and concepts • have the competence to choose and to explain appropriate metallic materials for special applications 		
Remarks: Scheduled every second summer semester.		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: Recommended: Knowledge of physical metallurgy and physical chemistry		
Frequency: each summer semester alternating with PHM-0167	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module

Part of the Module: Modern Metallic Materials

Mode of Instruction: lecture

Language: English

Contact Hours: 4

Literature:

Cahn-Haasen-Kramer: Materials Science and Technology

Original literature

Examination

Modern Metallic Materials

written exam / length of examination: 90 minutes

Examination Prerequisites:

Modern Metallic Materials

Module PHM-0193: Plasma Material Interaction <i>Plasma-Material-Wechselwirkung</i>		6 ECTS/LP
Version 2.2.0 (since WS17/18) Person responsible for module: apl. Prof. Dr.-Ing. Ursel Fantz		
Contents: <ul style="list-style-type: none"> Fundamentals of plasma material interactions (winter term) High heat load components in nuclear fusion devices (summer term) 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> Knowledge: The students know the fundamental plasma material interaction processes and their implication for nuclear fusion research in light of the technological boundary conditions and challenges. Skills: The students are proficient in a differentiated analysis of complex systems, based on learning from examples of power exhaust in fusion devices. Competencies: The students are competent in elaborating current topics of plasma material interaction. Integrated achievement of key qualifications: Acquirement of interdisciplinary knowledge, independent work with English literature, abstraction and approximation of complex processes using numerical models, application-oriented thinking and ability to contemplate about experimental results. 		
Remarks: The two lectures of this module can be followed in an arbitrary order. Thus, the module can be started at a summer or winter term.		
Workload: Total: 180 h 60 h studying of course content using provided materials (self-study) 60 h studying of course content using literature (self-study) 60 h lecture (attendance)		
Conditions: recommended: module "Plasmaphysik und Fusionsforschung"		Credit Requirements: general examination for entire module
Frequency: annually	Recommended Semester: from 2.	Minimal Duration of the Module: 2 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Fundamentals of plasma material interactions Mode of Instruction: lecture Language: English Frequency: each winter semester Contact Hours: 2		
Learning Outcome: see description of module		
Contents: Fundamental plasma boundary physics, erosion processes: physical sputtering, chemical erosion, radiation induced sublimation, arcs, experimental observation of surface processes in plasmas, methods for characterizing surfaces, coating techniques, hydrogen retention, surface modification by plasmas.		

<p>Literature:</p> <ul style="list-style-type: none"> • P. Stangeby: The plasma boundary of magnetic fusion devices (IOP, 2000) • R. Clark, D. Reiter (Eds.): Nuclear Fusion Research, Understanding Plasma-Surface Interactions (Springer, 2005) • O. Auciello, D. L. Flamm (Eds.): Plasma Diagnostics, Volume 2: Surface Analysis and Interactions (Plasma-Materials Interactions) (Academic Press, 1989) • M. Turnyanskiy et al.: European roadmap to the realization of fusion energy: Mission for solution on heat-exhaust systems (Fusion Engineering and Design, 2015)
<p>Assigned Courses:</p> <p>Fundamentals of plasma material interactions (lecture)</p>
<p>Part of the Module: High heat load components in nuclear fusion devices</p> <p>Mode of Instruction: lecture</p> <p>Language: English</p> <p>Frequency: each summer semester</p> <p>Contact Hours: 2</p>
<p>Learning Outcome:</p> <p>see description of module</p>
<p>Contents:</p> <p>Interdependency of material choices and fusion performance, material choices and technologies for power exhaust in a fusion power plant, migration of materials in a fusion plasma, diagnostics for plasma material interaction in fusion devices (in situ and post mortem), numerical methods for studying plasma material interaction.</p>
<p>Literature:</p> <ul style="list-style-type: none"> • P. Stangeby: The plasma boundary of magnetic fusion devices (IOP, 2000) • R. Clark, D. Reiter (Eds.): Nuclear Fusion Research, Understanding Plasma-Surface Interactions (Springer, 2005) • M. Turnyanskiy et al.: European roadmap to the realization of fusion energy: Mission for solution on heat-exhaust systems, Fusion Engineering and Design (2015) • V. A. Evtikhin et al.: Lithium divertor concept and results of supporting experiments, Plasma Phys. Control. Fusion 44, 955 (2002) • T. Hirai et al.: ITER tungsten divertor design development and qualification program, Fusion Eng. Des. 88, 1798 (2013) • A. R. Raffray et al.: High heat flux components - Readiness to proceed from near term fusion systems to power plants, Fusion Eng. Des. 85, 93 (2010)
<p>Examination</p> <p>Plasma Material Interaction</p> <p>oral exam / length of examination: 30 minutes</p>

Module PHM-0203: Physics of Cells <i>Physics of Cells</i>		6 ECTS/LP
Version 1.3.0 (since SoSe22) Person responsible for module: Dr. Christoph Westerhausen		
Contents: <ul style="list-style-type: none"> Physical principles in Biology Cell components and their material properties: cell membrane, organelles, cytoskeleton Thermodynamics of proteins and biological membranes Physical methods and techniques for studying cells Cell adhesion – interplay of specific, universal and elastic forces Tensile strength and elasticity of tissue - macromolecules of the extra cellular matrix Micro mechanics and properties of the cell as a biomaterial Cell adhesion Cell migration Cell actuation, cell-computer-communication, and cell stimulation 		
Learning Outcomes / Competences: The students <ul style="list-style-type: none"> know basic physical properties of human cells, as building blocks of living organisms and their material properties. know the basic functionality of mechanical and optical methods to study living cells know physical descriptions of fundamental biological processes and properties of biomaterials. are able to express biophysical questions and define model systems to answer these questions. The students improve the key competences: <ul style="list-style-type: none"> self-dependent working with English specialist literature. processing of experimental data. interdisciplinary thinking and working. 		
Workload: 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: Mechanics, Thermodynamics		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Physics of Cells		
Mode of Instruction: lecture		
Language: English / German		
Contact Hours: 2		
Learning Outcome: see module description		

Contents: see module description
Literature: <ul style="list-style-type: none">• Sackmann, Erich, and Rudolf Merkel. <i>Lehrbuch der Biophysik</i>. Wiley-VCH, 2010.• Heimburg, Thomas. <i>Thermal Biophysics of Membranes</i>. Wiley-VCH, 2007• Nelson, Philip. <i>Biological physics</i>. New York: WH Freeman, 2004.• Boal, D. <i>Mechanics of the Cell</i>. Cambridge University Press, 2012• Lecture notes
Assigned Courses: Physics of Cells (lecture)
Part of the Module: Physics of Cells (Tutorial) Mode of Instruction: exercise course Language: English Contact Hours: 2
Learning Outcome: see module description
Contents: see module description
Literature: see module description
Assigned Courses: Physics of Cells (Tutorial) (exercise course)
Examination Physics of Cells oral exam / length of examination: 30 minutes

Module PHM-0225: Analog Electronics for Physicists and Materials Scientists <i>Analog Electronics for Physicists and Materials Scientists</i>		6 ECTS/LP
Version 1.2.0 (since WS15/16) Person responsible for module: Andreas Hörner		
Contents: <ol style="list-style-type: none"> 1. Basics in electronic and electrical engineering 2. Quadrupole theory 3. Electronic Networks 4. Semiconductor Devices 5. Implementation of transistors 6. Operational amplifiers 7. Optoelectronic Devices 8. Measurement Devices 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic terms, concepts and phenomena of electronic and electrical engineering for the use in the Lab, • have skills in easy circuit design, measuring and control technology, analog electronics, • have expertise in independent working on circuit problems. They can calculate and develop easy circuits. 		
Workload: Total: 180 h 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study) 60 h lecture and exercise course (attendance)		
Conditions: none		
Frequency: each winter semester	Recommended Semester:	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Analog Electronics for Physicists and Materials Scientists Mode of Instruction: lecture + exercise Lecturers: Andreas Hörner Language: English Contact Hours: 4 ECTS Credits: 6.0		
Assigned Courses: Analog Electronics for Physicists and Materials Scientists (lecture + exercise)		
Examination Analog Electronics Analog Electronics for Physicists and Materials Scientists written exam / length of examination: 90 minutes Examination Prerequisites: Analog Electronics for Physicists and Materials Scientists		

Module PHM-0226: Digital Electronics for Physicists and Materials Scientists <i>Digital Electronics for Physicists and Materials Scientists</i>		6 ECTS/LP
Version 1.3.0 (since WS15/16) Person responsible for module: Andreas Hörner		
Contents: <ol style="list-style-type: none"> 1. Boolean algebra and logic gates 2. Digital electronics and calculation of digital circuits 3. Converters (Analog – Digital, Digital – Analog) 4. Principle of digital memory and communication, 5. Microprocessors and Networks 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic terms, concepts and phenomena of electronic and electrical engineering for the use in the Lab, • have skills in easy circuit design, measuring and control technology and digital electronics, • have expertise in independent working on circuit problems. They develop easy digital circuits and program microprocessors 		
Workload: Total: 180 h 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 60 h lecture and exercise course (attendance)		
Conditions: none		
Frequency: each summer semester	Recommended Semester:	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Digital Electronics for Physicists and Materials Scientists Mode of Instruction: lecture + exercise Lecturers: Andreas Hörner Language: English Contact Hours: 4 ECTS Credits: 6.0		
Examination Digital Electronics Digital Electronics for Physicists and Materials Scientists written exam / length of examination: 90 minutes		

Module PHM-0228: Symmetry concepts and their applications in solid state physics and materials science <i>Symmetry concepts and their applications in solid state physics and materials science</i>	6 ECTS/LP
Version 1.0.0 (since WS18/19) Person responsible for module: Prof. Dr. István Kézsmárki Deisenhofer, Joachim, Dr.	
<p>Contents:</p> <p>The topical outline of the course is as follows:</p> <ul style="list-style-type: none"> • Introduction and common examples <ul style="list-style-type: none"> o Motivating examples o Polar and axial vectors and tensors o Spatial and temporal symmetries and charge conjugation o Symmetries of measurable quantities and fields o Symmetries of physical laws (classical and quantum) o Conservation laws (linear and angular momentum, energy, etc.) o Symmetry of measurement configurations (reciprocity, etc.) • Neumann principle <ul style="list-style-type: none"> o Linear response theory and Onsager relations o Applications to vector and tensor quantities: electric and magnetic dipole moment of molecules; ferroelectricity, ferromagnetism, piezoelectricity and magnetoelectricity in crystals; wave propagation in anisotropic media (sound and light) • Symmetry allowed energy terms <ul style="list-style-type: none"> o On the level of classical free energy: Polar, nematic and magnetic order parameters (Landau expansion) o On the level of Hamiltonians: Molecular vibrations, crystal field potential, magnetic interactions • Symmetry of physical states <ul style="list-style-type: none"> o Spatial inversion and parity eigenstates o Discrete translations and the Bloch states • Spontaneous symmetry breaking upon phase transitions (Landau theory) • Outlook: Symmetry guides for skyrmion-host materials, multiferroic compounds and axion insulators 	
<p>Learning Outcomes / Competences:</p> <ul style="list-style-type: none"> • The students know the simple use of symmetry concepts to understand phenomena and material properties without performing detailed calculations. • The students know how to make minimal plans for experiments using the symmetry of the studied materials or vice versa how to determine the symmetry of materials from the output of experiments. • The students acquire scientific skills to search for scientific literature and to evaluate scientific content. 	
<p>Workload:</p> Total: 180 h 60 h (attendance) 60 h exam preparation (self-study) 60 h studying of course content (self-study)	

Conditions: Background in basic quantum mechanics is required.		
Frequency: nach Bedarf WS und SoSe	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
<p>Part of the Module: Symmetry concepts and their applications in solid state physics and materials science</p> <p>Mode of Instruction: lecture</p> <p>Lecturers: Prof. Dr. István Kézsmárki</p> <p>Language: English</p> <p>Contact Hours: 3</p> <p>ECTS Credits: 6.0</p>
<p>Examination</p> <p>Symmetry concepts and their applications in solid state physics and materials science</p> <p>oral exam / length of examination: 30 minutes</p>

Parts of the Module
<p>Part of the Module: Symmetry concepts and their applications in solid state physics and materials science (Tutorial)</p> <p>Mode of Instruction: exercise course</p> <p>Language: English</p> <p>Contact Hours: 1</p>

Module PHM-0252: Optical Excitations in Materials <i>Optical Excitations in Materials</i>		6 ECTS/LP
Version 1.9.0 (since SoSe20) Person responsible for module: Prof. Dr. Joachim Deisenhofer		
Contents: 1. Classical Light-Matter Interaction in Solids: <ul style="list-style-type: none"> • Introduction: Typical Optical Response of Metals and Semiconductors • Classical electromagnetic wave propagation in linear optical media (Maxwell Equations, refractive index, reflection, transmission, absorption) • Anisotropic media, birefringence, longitudinal solutions • Classical Drude-Lorentz oscillator model • Spectroscopic techniques: Fourier-Transform-Spectroscopy, Time-domain Spectroscopy, Ellipsometry 2. Quantum Aspects of Light-Matter interaction <ul style="list-style-type: none"> • qm approach to absorption and emission: Lorentzian lineshape, Fermi's Golden Rule • Electric-dipole and magnetic-dipole approximation • Rabi-oscillations and the need for quantum optical approaches • A glimpse of non-linear optics 3. Excitations in different material classes <ul style="list-style-type: none"> • Optical properties of semiconductors/insulators, molecular materials, metals • Absorption and Luminescence, excitons, luminescence centers • Optoelectronics, detectors, light emitting devices • Quantum confined structures: tuning of absorption and emission 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students gain basic knowledge of the fundamental concepts of light-matter interaction in solids. • The students have detailed knowledge of classical models of light-propagation and absorption and get the competence to choose adequate spectroscopic techniques for measuring the optical properties of different material classes. • The students have a basic understanding of quantum aspects of optical processes in different materials. • The students are able apply these concepts to understand and analyse optical properties of different materials. • The students acquire scientific skills to search for scientific literature and to evaluate scientific content. 		
Workload: Total: 180 h 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Basic knowledge of classical electrodynamics, atomic and solid state physics.		
Frequency: each semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module

Part of the Module: Optical Excitations in Materials

Mode of Instruction: lecture

Language: English

Contact Hours: 4

ECTS Credits: 6.0

Literature:

1. Mark Fox, Optical Properties of Solids, Oxford Master Series
2. Mark Fox, Quantum Optics: An Introduction, Oxford Master Series
3. David B. Tanner, Optical Effects in Solids, Cambridge University Press
4. Y. Toyozawa, Optical Processes in Solids, Cambridge University Press

Assigned Courses:

Optical Excitations in Materials (lecture)

Examination

Optical Excitations in Materials

written exam / length of examination: 90 minutes

Module PHM-0253: Dielectric Materials <i>Dielectric Materials</i>		6 ECTS/LP
Version 1.2.0 (since SoSe20) Person responsible for module: PD Dr. Peter Lunkenheimer		
Contents: <ul style="list-style-type: none"> • Experimental techniques: quantities, broadband dielectric spectroscopy, nonlinear and polarization measurements • Dynamic processes in dielectric materials: relaxation processes, phenomenological models • Dielectric properties of disordered matter: liquids, glasses, plastic crystals • Charge transport: hopping conductivity, universal dielectric response • Ionic conductivity: conductivity mechanism, dielectric properties, advanced electrolytes for energy-storage devices • Maxwell-Wagner relaxations: equivalent-circuits, applications (supercapacitors), colossal-dielectric-constant materials • Electroceramics: Materials, Properties (relaxor ferroelectric, ferroelectric, antiferroelectric and multiferroic), Applications 		
Learning Outcomes / Competences: Students know the fundamentals of electromagnetic wave propagation and have a sound background for a broad spectrum of dielectric phenomena. They are able to analyze materials requirements and to interpret dielectric spectra in a broad frequency range. They have the competence to select materials for different kinds of applications and to critically assess experimental results on dielectric properties.		
Remarks: Elective compulsory module		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: Basic knowledge of solid state physics		
Frequency: each summer semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Dielectric Materials Mode of Instruction: lecture Lecturers: PD Dr. Stephan Krohns, PD Dr. Peter Lunkenheimer Language: English / German		

Literature:

- F. Kremer and A. Schönhal (eds.), Broadband Dielectric Spectroscopy (Springer, Berlin, 2002).
- F. Kremer and A. Loidl (eds.), The scaling of relaxation processes (Springer, Cham, 2018).
- A.K. Jonscher, Dielectric Relaxations in Solids (Chelsea Dielectrics Press, London, 1983).
- C.J.F. Böttcher and P. Bordewijk, Theory of electric polarisation Vol II (Elsevier, Amsterdam, 1973).
- S.R. Elliott, Physics of Amorphous Materials (Longman, London, 1990)
- A.J.Moulson, J.M. Herbert, Electroceramics: Materials, Properties, Applications (Wiley, 2003)
- R. Waser, U. Böttger, S. Tiedke, Polar Oxides: Properties, Characterization, and Imaging (Wiley, 2005)

Examination

Dielectric Materials Dielectric Materials

presentation / length of examination: 45 minutes

Examination Prerequisites:

Dielectric Materials

Module PHM-0268: Porous Functional Materials <i>Poröse funktionale Materialien</i>	6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Dirk Volkmer	
Contents: (i) Einleitung und historischer Überblick (ii) Theorie (1) Wichtige Klassen poröser Materialien: Strukturen und Herstellungsmethoden a) Zeolithe, MCM-Materialien und silikatische Aergel b) Poröse Kohlenstoffe u. Kohlenstoffnitride c) Metall-Organische Gerüstverbindungen (MOFs) d) Kovalente Organische Gerüstverbindungen e) Poröse Flüssigkeiten und Gläser f) Flexible und Stimulus-responsive poröse Materialien (2) Physisorption in porösen Materialien a) Instrumentelle Methoden zur Bestimmung von spezifischer Oberfläche und Porosität b) Auswertung von Physisorptionsisothermen c) Atomistische Modellierung von Diffusion und Stofftransport (3) Ausgewählte Methoden der Struktur- und Thermoanalytik zur Charakterisierung poröser Materialien a) Thermoanalytische Methoden b) Dynamische Chemisorptionsanalyse c) Multikomponenten-Gasadsorption, Durchbruchkurven und IAST (iii) Anwendungen (4) Speicherung chemischer Stoffe in porösen Materialien a) Speicherung von wichtigen Energieträgern (H ₂ /Methan) b) CO ₂ -Fixierung c) Pharmakologischer Wirkstofftransport u.-freisetzung (5) Stofftrennprozesse a) Poröse Materialien in industriellen Trennprozessen b) Membran-Trenntechnologie (6) Heterogene Katalyse a) Zeolithe in der industriellen Katalyse b) Photokatalyse u. künstl. Photosynthese (7) Integration poröser Materialien in integrierte Schaltkreise und Sensoren	
Learning Outcomes / Competences: <ul style="list-style-type: none"> • Die Studierenden wissen die Designprinzipien, Herstellungs- und Charakterisierungsmethoden poröser Materialien, • wissen wichtige technische Anwendungen poröser Materialien • besitzen die Fertigkeit zur atomistischen Modellierung von porösen Materialien und Sorptionsprozessen • besitzen die Fertigkeit zur mathematischen Auswertung von Sorptions-analytischen Daten zur Bestimmung der spezifischen Oberfläche und Porosität der Materialien • besitzen Kompetenzen in der selbstständigen Bearbeitung von Problemstellungen aus den genannten Themenbereichen 	
Remarks: Das Modul kann in den Studiengängen Master Materialchemie und Master Materials Science and Engineering belegt werden	
Workload: Total: 180 h 30 h studying of course content using provided materials (self-study)	

30 h studying of course content using literature (self-study) 60 h studying of course content through exercises / case studies (self-study) 45 h lecture (attendance) 15 h exercise course (attendance)		
Conditions: keine		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 3.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module**Part of the Module: Poröse funktionale Materialien****Mode of Instruction:** lecture**Language:** German**Contact Hours:** 3**Lehr-/Lernmethoden:**

Beamerpräsentation, Blended Learning

Part of the Module: Übung zu Poröse funktionale Materialien**Mode of Instruction:** exercise course**Language:** German**Contact Hours:** 1**Lehr-/Lernmethoden:**

Tutorium, Beamerpräsentationen, Tafelanschrieb

Literature:

- Pascal Van Der Voort, Karen Leus, Els De Canck, Introduction to Porous Materials (Wiley, 1. Ausgabe 2019), ISBN-13 # : # 978-1119426608

Examination**Poröse funktionale Materialien**

oral exam, Einzel oder Gruppenprüfung (Prüfungsdauer pro Person) / length of examination: 30 minutes

Module PHM-0269: Materials for electrochemical energy storage <i>Materialien zur elektrochemischen Energiespeicherung</i>		6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Leo van Wüllen		
Contents: <ul style="list-style-type: none"> • elektrochemische Grundlagen • elektrochemische Energiespeicher: Superkondensatoren und Batterien • Batteriesysteme • Li-Ionen-Batterien • Redox-flow-Batterien • Metall-Fluorid-Batterien • Neue Materialien für Anode, Kathode, Elektrolyt und Separator 		
Learning Outcomes / Competences: Die Studierenden <ul style="list-style-type: none"> • kennen die grundlegenden Konzepte zur elektrochemischen Energiespeicherung • erhalten spezifische Kenntnisse über die wichtigsten aktuellen Batterie- und Akkumulatorsysteme • erhalten die Fertigkeit, für spezifische Einsatzfelder die geeigneten Batteriesysteme zu identifizieren • erwerben die Kompetenz, Materialien hinsichtlich ihrer Eignung als Anoden-, Kathoden- und Elektrolytmaterialien auszuwählen und zu beurteilen • Integrierter Erwerb von Schlüsselqualifikationen: Fähigkeit sich in ein naturwissenschaftliches Spezialgebiet einzuarbeiten und das erworbene Wissen aktiv zur Lösung wissenschaftlicher Fragestellungen anzuwenden 		
Remarks: Das Modul kann auch im Studiengang Master Materials Science and Engineering belegt werden.		
Workload: Total: 180 h 15 h exercise course (attendance) 45 h lecture (attendance) 120 h studying of course content using provided materials (self-study)		
Conditions: none		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Materialien zur elektrochemischen Energiespeicherung Mode of Instruction: lecture Language: German Contact Hours: 3		
Learning Outcome: siehe Modulbeschreibung		
Contents: siehe Modulbeschreibung		

Literature:

Hamann, C. H., Vielstich, W. (2005). *Elektrochemie*. (4. Auflage) Wiley-VCH Verlag GmbH.
Job, R. (2020). *Electrochemical Energy Storage*. Walter de Gruyter GmbH.
Kurzweil, P. (2015). *Elektrochemische Speicher: Superkondensatoren, Batterien, Elektrolyse-Wasserstoff, Rechtliche Rahmenbedingungen*. Springer-Verlag Berlin Heidelberg.

Part of the Module: Übung zu Materialien zur elektrochemischen Energiespeicherung

Mode of Instruction: exercise course

Language: German

Contact Hours: 1

Learning Outcome:

siehe Modulbeschreibung

Examination

Materialien zur elektrochemischen Energiespeicherung

oral exam, Einzel- oder Gruppenprüfung; Prüfungsdauer pro Person: 30 Minuten

Module PHM-0271: Photonic Materials <i>Photonische Materialien</i>		6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Henning Höppe		
Contents: <ul style="list-style-type: none"> • Einführung in grundlegende Konzepte • Silicatanaloge Materialien und Halbleiter • Lumineszierende Materialien • Pigmente • Anwendungsbeispiele • Grundsätze guter wissenschaftlicher Praxis 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • Die Studierenden kennen die grundlegenden theoretischen Konzepte (wie Ligandenfeld- und Bändertheorie), die zur Beschreibung charakteristischer Bindungsverhältnisse in Festkörpern notwendig sind; sie sind vertraut mit den Ordnungsprinzipien in Festkörpern (Kristallographie und Gruppentheorie) und verfügen über Grundkenntnisse in Stoffchemie und Festkörpersynthesen • Die Studierenden können die optischen Eigenschaften photonischer Materialien erklären und analysieren. • Sie erwerben die Kompetenz, ausgehend von bekannten Materialien die Eigenschaften neuer Verbindungen abzuschätzen und einen sinnvollen synthetisch-strategischen Zugang zu diesen Verbindungen zu erarbeiten. • Integrierter Erwerb von Schlüsselqualifikationen: Fähigkeit sich in ein naturwissenschaftliches Spezialgebiet einzuarbeiten und das erworbene Wissen aktiv zur Lösung wissenschaftlicher Fragestellungen anzuwenden 		
Remarks: Das Modul kann in den Studiengängen Master Materialchemie und Master Materials Science and Engineering belegt werden.		
Workload: Total: 180 h 15 h exercise course (attendance) 45 h lecture (attendance) 20 h studying of course content using provided materials (self-study) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study)		
Conditions: none		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Photonische Materialien Mode of Instruction: lecture Language: German Contact Hours: 3		
Learning Outcome: siehe Modulbeschreibung		

Contents:

siehe Modulbeschreibung

Literature:

- W. Yen, S. Shionoya, H. Yamamoto, Phosphor Handbook, The CRC Press laser and optical science and technology series, CRC Press/Taylor and Francis, 2007.
- B. Henderson und G. Imbusch, Optical spectroscopy of inorganic solids, Monographs on the Physics and Chemistry of Materials, Oxford University Press, 2006.
- A. Fox, Optical Properties of Solids, Oxford master series in condensed matter physics, Oxford University Press, 2001.
- weitere wird in der Vorlesung bekanntgegeben

Assigned Courses:

Photonische Materialien (lecture + exercise)

Part of the Module: Übung zu Photonische Materialien

Mode of Instruction: exercise course

Language: German

Contact Hours: 1

Learning Outcome:

siehe Modulbeschreibung

Examination

Photonische Materialien

written exam / length of examination: 90 minutes

Module PHM-0274: Materials under extreme conditions <i>Materialien unter extremen Bedingungen</i>		6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Wolfgang Scherer		
Contents: <ul style="list-style-type: none"> • Einführung in die Hochtemperatur- und Hochdruckchemie in Lösung und im Festkörper • Experimentelle Techniken zur Synthese und Charakterisierungen von Materialien unter extremen Bedingungen • Einfluss von Druck und Temperatur auf die Reaktionen anorganischer und organischer Verbindungen • Materialeigenschaften und physikalischen Eigenschaften von Festkörpern unter extremen Bedingungen • Anwendungen in der Hochdruckchemie und Design von Materialien 		
Learning Outcomes / Competences: Die Studierenden <ul style="list-style-type: none"> • erlangen Grundkenntnisse in der Synthese und <i>in-situ</i> Charakterisierung von Festkörpern und molekularen Materialien bei hohem Druck und hohen Temperaturen. • kennen die grundlegenden Konzepte, die zum Verständnis der komplexen Bindungsverhältnisse, Strukturchemie und physikalischer Eigenschaften von Materialien unter extremen Bedingungen unabdingbar sind: <ul style="list-style-type: none"> - Molekülorbitaltheorie - Bandstrukturanalyse - Ligandenfeldtheorie - spektroskopische Methoden - Beugungsmethoden • erlangen die Fähigkeit strukturelle und physikalische Phasenübergänge in Abhängigkeit von Druck und Temperatur zu analysieren und interpretieren. • können grundlegende Strategien anwenden, um die elektronische Struktur von Festkörpern und damit die Materialeigenschaften in Abhängigkeit externer Kontrollparameter (Druck, Temperatur) maßzuschneidern. Damit erwerben sie die Schlüsselqualifikation, sich in ein naturwissenschaftliches Spezialgebiet einzuarbeiten und das erworbene Wissen zur Lösung anwendungsorientierter Fragestellungen, wie dem Design von Materialien mit maßgeschneiderten physikalischen Eigenschaften, umzusetzen. 		
Remarks: Das Modul kann in den Studiengängen Master "Materialchemie" und Master "Materials Science and Engineering" belegt werden.		
Workload: Total: 180 h 45 h lecture (attendance) 15 h exercise course (attendance) 30 h studying of course content using literature (self-study) 60 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using provided materials (self-study)		
Conditions: none		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 3.	Minimal Duration of the Module: 1 semester[s]

Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
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Parts of the Module**Part of the Module: Materialien unter extremen Bedingungen****Mode of Instruction:** lecture**Language:** German**Contact Hours:** 3**Learning Outcome:**

siehe Modulbeschreibung

Contents:

siehe Modulbeschreibung

Lehr-/Lernmethoden:

Vorlesung, Beamerpräsentation, Tafelanschrieb

Literature:

- R. van Eldik, F.-G. Klärner, *High Pressure Chemistry: Synthetic, Mechanistic, and Supercritical Applications*, WILEY-VCH, 1st Ed., 2002
- V.D. Blank, E.I. Estrin, *Phase Transitions in Solids Under High Pressure*, CRC Press, 1st Ed., 2014.
- J. Gilman, *Electronic Basis of the Strength of Materials*, Cambridge, 1st Ed., 2014.
- R. M. Hazen, R.T. Downs, *High-Temperature and High-Pressure Crystal Chemistry*, Mineralogical Society of America, 2000.
- U. Schubert, N. Hüsing, *Synthesis of Inorganic Materials*, Wiley-VCH, 3rd Edition, 2012.
- N. Wiberg, *Lehrbuch der Anorganischen Chemie*, Walter de Gruyter, ebook, 102. Auflage, 2007.

Part of the Module: Übungen zu Materialien unter extremen Bedingungen**Mode of Instruction:** exercise course**Language:** German**Contact Hours:** 1**Learning Outcome:**

siehe Modulbeschreibung

Examination**Materialien unter extremen Bedingungen**

written exam / length of examination: 90 minutes

Module INF-0277: Analyzing Massive Data Sets <i>Analyzing Massive Data Sets</i>		8 ECTS/LP
Version 1.2.0 (since SoSe18) Person responsible for module: Prof. Dr. Peter Michael Fischer		
<p>Learning Outcomes / Competences: After attending the course, students will be able to understand and evaluate the concepts and methods, procedures, techniques, and technologies for analyzing massively large data sets. Possible content includes:</p> <ul style="list-style-type: none"> • Fundamentals of information retrieval • Similarity search and clustering • Analysis of data streams and temporal data • Web graphs: Link analysis and social networks • Dynamic networks and information diffusion • Recommender systems and online advertising • Computational methods for massive data sets <p>Students will also be able to implement technical solution concepts for analyzing large data sets in programs. Key Skills: Ability to think logically, analytically and conceptually, weigh up approaches to solutions, acquire abstraction skills; subject-specific in-depth knowledge; implement subject-specific solution concepts in programs and models; knowledge of the advantages/disadvantages of design alternatives and evaluation in the respective application context; selection and confident application of suitable methods; ability to make scientifically meaningful evaluations using suitable methods; ability to solve problems under practical boundary conditions; competence in recognizing significant technical developments;</p>		
<p>Workload: Total: 240 h 30 h studying of course content using literature (self-study) 90 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using provided materials (self-study) 60 h lecture (attendance) 30 h exercise course (attendance)</p>		
<p>Conditions: Module Database Systems (INF-0073) - recommended Module Discrete structures for computer science (INF-0109) - recommended Module Computer Science 3 (INF-0111) - recommended</p>		
Frequency: irregular (usu. summer semester)	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
<p>Part of the Module: Analyzing Massive Data Sets (Vorlesung) Mode of Instruction: lecture Language: English Contact Hours: 4</p>		
<p>Contents: The lecture covers basic concepts for the analysis of massively large data sets such as information extraction, similarity search, clustering, link and network analysis as well as their implementation.</p>		

Literature:

- Mining of Massive Datasets. J. Leskovec, A. Rajaraman, J.D. Ullman. Cambridge University Press, 2014
- D. Easley, J. Kleinberg. Networks, Crowds, and Markets: Reasoning About a Highly Connected World. Cambridge University Press, 2010.
- R. Baeza-Yates, B. Ribeiro-Neto: Modern Information Retrieval

Weitere Literatur wird in der Vorlesung bekannt gegeben

Part of the Module: Analyzing Massive Data Sets (Übung)

Mode of Instruction: exercise course

Language: English / German

Contact Hours: 2

Examination

Analyzing Massive Data Sets

written exam / length of examination: 90 minutes

Module INF-0316: Machine Learning and Computer Vision <i>Machine Learning and Computer Vision</i>		8 ECTS/LP
Version 1.0.0 (since SoSe19) Person responsible for module: Prof. Dr. Rainer Lienhart		
<p>Learning Outcomes / Competences: After successful participation in this module, students possess advanced knowledge of machine learning (decision trees, neural networks and deep neural networks, hypothesis evaluation, instance-based learning, Bayesian learning, learning theory), data reduction (e.g. principal component analysis), advanced image processing and machine vision and are able to apply them. They can analyse, understand and programmatically implement scientifically complex procedures in the field of multimedia data processing, as well as to appropriately apply the principles learned to new problems. They develop skills in logical, analytical and conceptual thinking in the field of digital signal processing and multimedia data processing.</p> <p>Key qualifications: advanced mathematical-formal logic; implementation of subject-specific solution concepts; interdisciplinary knowledge; development and implementation of solution strategies for complex problems; systematic further development of design methods; ability to solve problems under practical boundary conditions.</p>		
<p>Workload: Total: 240 h 30 h exercise course (attendance) 60 h lecture (attendance) 30 h studying of course content using provided materials (self-study) 90 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using literature (self-study)</p>		
Conditions: none		
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Machine Learning and Computer Vision (Lecture)		
Mode of Instruction: lecture		
Language: German		
Contact Hours: 4		
<p>Contents: The lecture gives a good overview of all aspects of machine learning and machine extraction of information from multimedia data (e.g. "Google Image Search", "Google Goggles"). The learned concepts will be practised, analysed, and evaluated in the exercises using successful examples from practice. At the end of the semester, advanced topics such as object detection and object recognition of faces and people will be covered. The contents of the lecture include: Machine Learning (Decision Tree Learning, Artificial Neural Networks, Bayesian Learning, Discrete Adaboost), Data Reduction (Quantization (K-Means Clustering, Affinity Propagation), Dimensionality Reduction Techniques (PCA, NMF, Random Projection, MDS)) and Image Processing & Computer Vision (Salient Feature Points and Feature Descriptors, Object Detection (Face/Car/People Detection), Object Recognition (Face Recognition), Image Search with pLSA).</p>		
<p>Literature: Literature references will be announced at the beginning of the semester.</p>		

Part of the Module: Machine Learning and Computer Vision (Tutorial)

Mode of Instruction: exercise course

Language: German

Contact Hours: 2

Examination

Machine Learning and Computer Vision (Exam)

written exam / length of examination: 120 minutes

Description:

The examination can be taken every semester during the examination period.

Module MRM-0112: Finite element modeling of multiphysics phenomena <i>Finite-Elemente-Modellierung von Multiphysik-Phänomenen</i>		6 ECTS/LP
Version 2.9.0 (since WS19/20) Person responsible for module: Prof. Dr. Markus Sause Dozenten: Prof. Dr. Sause / Prof. Dr Peter		
Learning Outcomes / Competences: The students <ul style="list-style-type: none"> • get to know existing numerical methods for modeling and simulation of physical processes and systems • Learn the use and application of numerical methods for realistic problems • Are able to apply basic functional principles of a FEM program by using "COMSOL Multiphysics". 		
Remarks: This module is offered by faculty from MRM and Mathematics. It is intended for physics, MSE and WING students, who want to get an insight into a modern FEM program as it is used in academic and industrial applications.		
Workload: Total: 180 h		
Conditions: Recommended: MTH-6110 - Numerische Verfahren für Materialwissenschaftler, Physiker und Wirtschaftsingenieure		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Finite-Elemente-Modellierung von Multiphysik-Phänomenen		
Mode of Instruction: lecture Lecturers: Prof. Dr. Malte Peter, Prof. Dr. Markus Sause Language: German Contact Hours: 2		
Contents: The following content will be presented: <ul style="list-style-type: none"> • Modeling and simulation of physical processes and systems. • Basic concepts of FEM programs • Generation of meshes • Optimization strategies • Selection of solver algorithms • Example applications from electrodynamics • Example applications from thermodynamics • Example applications from continuum mechanics • Example applications from fluid dynamics • Coupling of differential equations for the solution of multiphysics phenomena 		
Lehr-/Lernmethoden: Slide presentation, classroom discussion		

Literature:

- Grossmann, C., Roos, H.-G., & Stynes, M. (2007). Numerical Treatment of Partial Differential Equations. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-540-71584-9>
- Eck, C., Garcke, H., & Knabner, P. (2017). Mathematische Modellierung. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-662-54335-1>
- Temam, R., & Miranville, A. (2005). Mathematical Modeling in Continuum Mechanics. Cambridge: Cambridge University Press.

Examination

Finite-Elemente-Modellierung von Multiphysik-Phänomenen

written/oral exam / length of examination: 60 minutes

Parts of the Module

Part of the Module: Übung zu Finite-Elemente-Modellierung von Multiphysik-Phänomenen

Mode of Instruction: exercise course

Language: German

Contact Hours: 2

Lehr-/Lernmethoden:

Independent reflection of topics to deepen the lecture content

Module MRM-0152: Continuum Mechanics and Material Modeling <i>Continuum Mechanics and Material Modeling</i>		6 ECTS/LP
Version 1.0.0 Person responsible for module: Prof. Dr.-Ing. Christian Weißenfels		
Contents: <ol style="list-style-type: none"> 1. Tensor calculus 2. Kinematics 3. Stresses 4. Balance laws 5. Elasticity 6. Plasticity 7. Viscoelasticity 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students know the principal concepts of continuum mechanics • The students know the basic concepts to formulate constitutive equations • The students have the competence to describe specific material behavior • The students are able to apply their knowledge to solve simple engineering problems • Integrated acquirement of soft skills: Ability to connect abstract mathematical formulations to real behavior 		
Workload: Total: 180 h 45 h lecture and exercise course (attendance) 135 h studying of course content using provided materials (self-study)		
Conditions: Basic knowledge of engineering mechanics.		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 3	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Continuum Mechanics and Material Modeling Mode of Instruction: lecture Language: English Contact Hours: 2		
Learning Outcome: See description of module.		
Contents: See description of module.		
Literature: <ul style="list-style-type: none"> • G. Holzapfel: Nonlinear Solid Mechanics (John Wiley & Sons, 2000) • J. Lemaitre, J.L. Chaboche: Mechanics of Solid Materials (Cambridge Univ. Press, 1990) • P. Haupt: Continuum Mechanics and Theory of Materials (Springer, 2002) 		
Examination Continuum Mechanics and Material Modeling oral exam / length of examination: 30 minutes		

Parts of the Module
Part of the Module: Exercise to Continuum Mechanics and Material Modeling Mode of Instruction: exercise course Language: English Contact Hours: 1
Learning Outcome: See description of module.
Contents: See description of module.

Module PHM-0174: Theoretical Concepts and Simulation <i>Theoretical Concepts and Simulation</i>		6 ECTS/LP
Version 1.0.0 (since WS09/10) Person responsible for module: Prof. Dr. Liviu Chioncel		
Contents: <ol style="list-style-type: none"> 1. Introduction: operating systems, programming languages, data visualization tools 2. Basic numerical methods: interpolation, integration 3. Ordinary and Partial Differential Equations (e.g., diffusion equation, Schrödinger equation) 4. Molecular dynamics 5. Monte Carlo simulations 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the principal concepts of thermodynamics and statistical physics as well as the numerical methods relevant in material science, • are able to solve simple problems numerically. They are able to write the codes and to present the results, • have the expertise to find the numerical method appropriate for the given problem and to judge the quality and validity of the numerical results, • Integrated acquirement of soft skills: independent handling of hard- and software while using English documentations, ability to investigate abstract circumstances with the help of a computer and present the results in written and oral form, capacity for teamwork. 		
Remarks: Links to software related to the course: <ul style="list-style-type: none"> • http://www.bloodshed.net/ • http://www.cplusplus.com/doc/tutorial/ • http://www.cygwin.com/ • http://xmd.sourceforge.net/download.html • http://www.rasmol.org/ • http://felt.sourceforge.net/ 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study)		
Conditions: Recommended: basic knowledge of quantum mechanics, thermodynamics, and numerical methods as well as of a programming language		Credit Requirements: project work in small groups, including a written summary of the results (ca. 10-20 pages) as well as an oral presentation
Frequency: each summer semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module

Part of the Module: Theoretical Concepts and Simulation

Mode of Instruction: lecture

Language: English

Contact Hours: 3

Literature:

- Tao Pang, An Introduction to Computational Physics (Cambridge University Press)
- J. M. Thijssen, Computational Physics (Cambridge University Press)
- Koonin, Meredith, Computational Physics (Addison-Weseley)
- D. C. Rapaport, The Art of Molecular Dynamics Simulation, (Cambridge University Press)
- W. H. Press et al, Numerical Recipes (Cambridge University Press)

Part of the Module: Theoretical Concepts and Simulation (Project)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Theoretical Concepts and Simulation

seminar / length of examination: 30 minutes

Examination Prerequisites:

Theoretical Concepts and Simulation

Module MRM-0087: Sustainable Chemistry of Materials and Resources - Chemical Reactions and Cycles <i>Nachhaltige Chemie der Materialien und Ressourcen - Reaktionen und Kreisläufe</i>		6 ECTS/LP
Version 1.0.0 (since SoSe16) Person responsible for module: Prof. Dr. Richard Wehrich		
Contents: <ul style="list-style-type: none"> • Introduction: resources and materials • Demand of resources and materials: principles and megatrends • Sustainability, criticality and resource efficiency: principles and concepts • Mining, preparation, and processing of raw materials like Si, Fe, Cu, Al, Ga, Ag, Au, Pt • Methods of separation and purification of raw materials • Methods of synthesis and preparations of functional materials from solid, liquid, and gaseous phase • Thermodynamics, kinetics, and reversibility of chemical reactions • Recycling, and circular use of resources 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students know the basic terms and concepts of sustainability, criticality and use of materials and resources • The students know the basic terms and concepts of chemical processing of raw and functional materials • The students have the competence to explain chemical processes of purification and preparation and describe their specific use. • The students are able to describe need of resources and energy of relevant processes. • The students are able to classify materials and processes with respect to sustainability, demand of raw materials, and circularity. • The students acquire scientific skills to search for scientific literature and to evaluate scientific content. 		
Workload: Total: 180 h		
Conditions: none		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 4.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: any	
Parts of the Module		
Part of the Module: Nachhaltige Chemie der Materialien und Ressourcen - Reaktionen und Kreisläufe Mode of Instruction: lecture Language: English / German Contact Hours: 2		

Literature:

- A. Reller, M. Marschall, S. Meißner, C. Schmid, Ressourcenstrategien, Eine Einführung in den nachhaltigen Umgang mit Ressourcen, wbg Academic in Wissenschaftliche Buchgesellschaft 2013, ISBN: 3534259149.
- U. Schubert, N. Hüsing, Synthesis of Inorganic Materials, 4. Aufl. 2019, Wiley-VCH, ISBN: # 3527344578;
- A. R. West, Solid State Chemistry and its Applications, 2nd Edition, Student Edition, ISBN: 978-1-119-94294-8, 584, 2014;
- A. R. West, Solid State Chemistry and its Applications, Wiley, 2022, ISBN: 1118447441.
- A. Wold, K. Dwight, Solid State Chemistry: Synthesis, Springer, 2009, ISBN 978-0412036217;
- T. E. Warner, Synthesis, Properties and Mineralogy of Important Inorganic Materials, Wiley, 2011, ISBN 978-0470746110;
- G. Kickelbick, Hybrid Materials: Synthesis, Characterisation and Applications, 2006, ISBN 978-3527312993;
- D. Vollath, Nanomaterials: An Introduction to Synthesis, Properties, and Applications, Wiley-VCH, 2013, 978-3527333790;
- M. Bertau, A. Müller, P. Fröhlich, M. Katzberg, Industrielle Anorg. Chemie, Wiley-VCH, 2013, ISBN 978-3527330195;

Assigned Courses:

Nachhaltige Chemie der Materialien und der Ressourcen – Reaktionen und Kreisläufe (lecture)

Übung: Nachhaltige Chemie der Materialien und der Ressourcen – Reaktionen und Kreisläufe (exercise course)

Examination

Nachhaltige Chemie der Materialien und Ressourcen - Reaktionen und Kreisläufe

written exam / length of examination: 90 minutes

Parts of the Module

Part of the Module: Übung zu Nachhaltige Chemie der Materialien und Ressourcen - Reaktionen und Kreisläufe

Mode of Instruction: exercise course

Language: English / German

Contact Hours: 2

Assigned Courses:

Nachhaltige Chemie der Materialien und der Ressourcen – Reaktionen und Kreisläufe (lecture)

Übung: Nachhaltige Chemie der Materialien und der Ressourcen – Reaktionen und Kreisläufe (exercise course)

Module PHM-0167: Oxidation and Corrosion <i>Oxidation and Corrosion</i>	6 ECTS/LP
Version 1.0.0 (since SoSe15) Person responsible for module: Prof. Dr. Ferdinand Haider	
Contents: Introduction Review of thermodynamics Chemical equilibria Electrochemistry Electrode kinetics High temperature oxidation Localized corrosion <ul style="list-style-type: none"> • Shallow pit corrosion • Pitting corrosion • Crevice corrosion • Intercrystalline corrosion • Stress corrosion cracking • Fatigue corrosion • Erosion corrosion • Galvanic corrosion Water and seawater corrosion Corrosion monitoring Corrosion properties of specific materials Specific corrosion problems in certain branches <ul style="list-style-type: none"> • Oil and Gas industry • Automobile industry • Food industry Corrosion protection <ul style="list-style-type: none"> • Passive layers • Reaction layers (Diffusion layers ...) • Coatings (organic, inorganic) • Cathodic, anodic protection • Inhibitors 	
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the the fundamental basics, mechanics, types of corrosion processes and their electrochemical explanation • obtain the skill to understand typical electrochemical quantification of corrosion processes. • acquire the competence to assess corrosion phenomena from typical damage patterns 	
Remarks: Scheduled every second summer semester.	
Workload: Total: 180 h 60 h lecture and exercise course (attendance)	

120 h studying of course content using provided materials (self-study)		
Conditions: Recommended: good knowledge in materials science, basic knowledge in physical chemistry		Credit Requirements: written exam (90 min)
Frequency: each summer semester alternating with PHM-0168	Recommended Semester: from 3.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module**Part of the Module: Oxidation and Corrosion****Mode of Instruction:** lecture**Language:** English**Frequency:** each winter semester**Contact Hours:** 3**Literature:**

- Schütze: Corrosion and Environmental Degradation

Part of the Module: Oxidation and Corrosion (Tutorial)**Mode of Instruction:** exercise course**Language:** English**Frequency:** each winter semester**Contact Hours:** 1**Examination****Oxidation and Corrosion**

written exam / length of examination: 90 minutes

Examination Prerequisites:

Oxidation and Corrosion

Module PHM-0266: Analytical Methods for Crystalline Sustainable Materials <i>Analytical Methods for Crystalline Sustainable Materials</i>		6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Christine Kuntscher		
Contents: The course will introduce diffraction methods and various spectroscopic methods including x-ray diffraction, energy-dispersive x-ray spectroscopy, photoemission spectroscopy, infrared and Raman spectroscopy, scanning electron microscopy, and scanning tunneling microscopy and spectroscopy.		
Learning Outcomes / Competences: After attending the course, the students will know the physical basics of various analytical methods and their possible applications for the characterization of crystalline sustainable materials.		
Workload: Total: 180 h 120 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Recommended: good knowledge in materials science		Credit Requirements: Bestehen der Modulprüfung
Frequency:	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Analytical Methods for Crystalline Sustainable Materials Mode of Instruction: lecture Language: English / German Contact Hours: 4		
Literature: J. M. Hollas, Modern Spectroscopy, Wiley-VCH (2003) H. Kuzmany, Solid State Spectroscopy, Springer (2009) S. Hüfner, Photoelectron Spectroscopy, Springer (1995)		
Part of the Module: Übung zu Analytical Methods for Crystalline Sustainable Materials Mode of Instruction: exercise course Language: English / German Contact Hours: 1		
Examination Analytical Methods for Crystalline Sustainable Materials written exam / length of examination: 90 minutes		

Module PHM-0267: Fundamentals of Materials for Energy <i>Fundamentals of Materials for Energy</i>		6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Wolfgang Brütting		
Contents: This class teaches fundamentals of conventional as well as renewable energy conversion. The following topics will be addressed: <ul style="list-style-type: none"> • Basics facts on energy conversion and climate change • Fossil energy • Nuclear energy • Renewable energy • Energy storage and transport 		
Learning Outcomes / Competences: Students know the fundamentals of different energy technologies. They are able to assess their respective efficiency and their potential for covering current and future energy demand. They are able to deal with a specific problem using up-to-date literature and participate in the ongoing discussion about how to cover our increasing need for various forms of energy.		
Conditions: Sound background in physics, in particular solid state physics and thermodynamics.		Credit Requirements: Passing the exam
Frequency: annually	Recommended Semester:	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Fundamentals of Materials for Energy Mode of Instruction: lecture Language: English / German Contact Hours: 4 ECTS Credits: 6.0		
Literature: <ul style="list-style-type: none"> • D.S. Ginley, D. Cahen: Fundamentals of Materials for Energy and Environmental Sustainability (Cambridge Univ. Press) • J. Fricke, W.L. Borst: Essentials of Energy Technology (Wiley-VCH) • D.J.C. MacKay: Sustainable Energy - without the hot air (https://www.withouthotair.com/) 		
Assigned Courses: Fundamentals of Materials for Energy (lecture)		
Examination Fundamentals of Materials for Energy written exam / length of examination: 90 minutes		

Module INF-0277: Analyzing Massive Data Sets <i>Analyzing Massive Data Sets</i>		8 ECTS/LP
Version 1.2.0 (since SoSe18) Person responsible for module: Prof. Dr. Peter Michael Fischer		
<p>Learning Outcomes / Competences: After attending the course, students will be able to understand and evaluate the concepts and methods, procedures, techniques, and technologies for analyzing massively large data sets. Possible content includes:</p> <ul style="list-style-type: none"> • Fundamentals of information retrieval • Similarity search and clustering • Analysis of data streams and temporal data • Web graphs: Link analysis and social networks • Dynamic networks and information diffusion • Recommender systems and online advertising • Computational methods for massive data sets <p>Students will also be able to implement technical solution concepts for analyzing large data sets in programs. Key Skills: Ability to think logically, analytically and conceptually, weigh up approaches to solutions, acquire abstraction skills; subject-specific in-depth knowledge; implement subject-specific solution concepts in programs and models; knowledge of the advantages/disadvantages of design alternatives and evaluation in the respective application context; selection and confident application of suitable methods; ability to make scientifically meaningful evaluations using suitable methods; ability to solve problems under practical boundary conditions; competence in recognizing significant technical developments;</p>		
<p>Workload: Total: 240 h 30 h studying of course content using literature (self-study) 90 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using provided materials (self-study) 60 h lecture (attendance) 30 h exercise course (attendance)</p>		
<p>Conditions: Module Database Systems (INF-0073) - recommended Module Discrete structures for computer science (INF-0109) - recommended Module Computer Science 3 (INF-0111) - recommended</p>		
Frequency: irregular (usu. summer semester)	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
<p>Part of the Module: Analyzing Massive Data Sets (Vorlesung) Mode of Instruction: lecture Language: English Contact Hours: 4</p>		
<p>Contents: The lecture covers basic concepts for the analysis of massively large data sets such as information extraction, similarity search, clustering, link and network analysis as well as their implementation.</p>		

Literature:

- Mining of Massive Datasets. J. Leskovec, A. Rajaraman, J.D. Ullman. Cambridge University Press, 2014
- D. Easley, J. Kleinberg. Networks, Crowds, and Markets: Reasoning About a Highly Connected World. Cambridge University Press, 2010.
- R. Baeza-Yates, B. Ribeiro-Neto: Modern Information Retrieval

Weitere Literatur wird in der Vorlesung bekannt gegeben

Part of the Module: Analyzing Massive Data Sets (Übung)

Mode of Instruction: exercise course

Language: English / German

Contact Hours: 2

Examination

Analyzing Massive Data Sets

written exam / length of examination: 90 minutes

Module INF-0316: Machine Learning and Computer Vision <i>Machine Learning and Computer Vision</i>		8 ECTS/LP
Version 1.0.0 (since SoSe19) Person responsible for module: Prof. Dr. Rainer Lienhart		
<p>Learning Outcomes / Competences: After successful participation in this module, students possess advanced knowledge of machine learning (decision trees, neural networks and deep neural networks, hypothesis evaluation, instance-based learning, Bayesian learning, learning theory), data reduction (e.g. principal component analysis), advanced image processing and machine vision and are able to apply them. They can analyse, understand and programmatically implement scientifically complex procedures in the field of multimedia data processing, as well as to appropriately apply the principles learned to new problems. They develop skills in logical, analytical and conceptual thinking in the field of digital signal processing and multimedia data processing.</p> <p>Key qualifications: advanced mathematical-formal logic; implementation of subject-specific solution concepts; interdisciplinary knowledge; development and implementation of solution strategies for complex problems; systematic further development of design methods; ability to solve problems under practical boundary conditions.</p>		
<p>Workload: Total: 240 h 30 h exercise course (attendance) 60 h lecture (attendance) 30 h studying of course content using provided materials (self-study) 90 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using literature (self-study)</p>		
Conditions: none		
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Machine Learning and Computer Vision (Lecture)		
Mode of Instruction: lecture		
Language: German		
Contact Hours: 4		
<p>Contents: The lecture gives a good overview of all aspects of machine learning and machine extraction of information from multimedia data (e.g. "Google Image Search", "Google Goggles"). The learned concepts will be practised, analysed, and evaluated in the exercises using successful examples from practice. At the end of the semester, advanced topics such as object detection and object recognition of faces and people will be covered. The contents of the lecture include: Machine Learning (Decision Tree Learning, Artificial Neural Networks, Bayesian Learning, Discrete Adaboost), Data Reduction (Quantization (K-Means Clustering, Affinity Propagation), Dimensionality Reduction Techniques (PCA, NMF, Random Projection, MDS)) and Image Processing & Computer Vision (Salient Feature Points and Feature Descriptors, Object Detection (Face/Car/People Detection), Object Recognition (Face Recognition), Image Search with pLSA).</p>		
<p>Literature: Literature references will be announced at the beginning of the semester.</p>		

Part of the Module: Machine Learning and Computer Vision (Tutorial)

Mode of Instruction: exercise course

Language: German

Contact Hours: 2

Examination

Machine Learning and Computer Vision (Exam)

written exam / length of examination: 120 minutes

Description:

The examination can be taken every semester during the examination period.

Module MRM-0025: Fiber Reinforced Polymers for Engineers <i>Faserverbundkunststoffe - Produktion und Anwendung</i>		6 ECTS/LP
Version 1.0.0 (since WS15/16) Person responsible for module: Prof. Dr.-Ing. Michael Kupke		
Learning Outcomes / Competences: Die Studierenden - kennen die Vor- und Nachteile von Faserverbundwerkstoffen in Herstellung und Anwendung - haben ein Verständnis über faserverbundgerechte Bauweisen - kennen das Prinzip der Bauweisenbewertung für das Produkt		
Remarks: Ansprechpartnerin: Prof. Dr.-Ing. Michael Kupke, Tobias Karrasch (tobias.karrasch@mrm.uni-augsburg.de)		
Workload: Total: 180 h		
Conditions: none		Credit Requirements: Schriftliche Prüfung
Frequency: each semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 2	Repeat Exams Permitted: any	
Parts of the Module		
Part of the Module: Faserverbundkunststoffe für Ingenieure Mode of Instruction: lecture Lecturers: Prof. Dr.-Ing. Michael Kupke Language: German Contact Hours: 2		
Contents: 1. Grundlagen 2. Herstellung 3. Produktion 4. Anwendung		
Lehr-/Lernmethoden: Tafelanschrift und Beamerpräsentation		
Literature: wird in der Vorlesung bekannt gegeben		
Assigned Courses: Faserverbundkunststoffe – Produktion und Anwendung (Faserverbundkunststoffe für Ing.) (lecture)		
Examination Faserverbundkunststoffe für Ingenieure written exam, Schriftliche Prüfung		

Module MRM-0087: Sustainable Chemistry of Materials and Resources - Chemical Reactions and Cycles <i>Nachhaltige Chemie der Materialien und Ressourcen - Reaktionen und Kreisläufe</i>		6 ECTS/LP
Version 1.0.0 (since SoSe16) Person responsible for module: Prof. Dr. Richard Wehrich		
Contents: <ul style="list-style-type: none"> • Introduction: resources and materials • Demand of resources and materials: principles and megatrends • Sustainability, criticality and resource efficiency: principles and concepts • Mining, preparation, and processing of raw materials like Si, Fe, Cu, Al, Ga, Ag, Au, Pt • Methods of separation and purification of raw materials • Methods of synthesis and preparations of functional materials from solid, liquid, and gaseous phase • Thermodynamics, kinetics, and reversibility of chemical reactions • Recycling, and circular use of resources 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students know the basic terms and concepts of sustainability, criticality and use of materials and resources • The students know the basic terms and concepts of chemical processing of raw and functional materials • The students have the competence to explain chemical processes of purification and preparation and describe their specific use. • The students are able to describe need of resources and energy of relevant processes. • The students are able to classify materials and processes with respect to sustainability, demand of raw materials, and circularity. • The students acquire scientific skills to search for scientific literature and to evaluate scientific content. 		
Workload: Total: 180 h		
Conditions: none		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 4.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: any	
Parts of the Module		
Part of the Module: Nachhaltige Chemie der Materialien und Ressourcen - Reaktionen und Kreisläufe Mode of Instruction: lecture Language: English / German Contact Hours: 2		

Literature:

- A. Reller, M. Marschall, S. Meißner, C. Schmid, Ressourcenstrategien, Eine Einführung in den nachhaltigen Umgang mit Ressourcen, wbg Academic in Wissenschaftliche Buchgesellschaft 2013, ISBN: 3534259149.
- U. Schubert, N. Hüsing, Synthesis of Inorganic Materials, 4. Aufl. 2019, Wiley-VCH, ISBN: # 3527344578;
- A. R. West, Solid State Chemistry and its Applications, 2nd Edition, Student Edition, ISBN: 978-1-119-94294-8, 584, 2014;
- A. R. West, Solid State Chemistry and its Applications, Wiley, 2022, ISBN: 1118447441.
- A. Wold, K. Dwight, Solid State Chemistry: Synthesis, Springer, 2009, ISBN 978-0412036217;
- T. E. Warner, Synthesis, Properties and Mineralogy of Important Inorganic Materials, Wiley, 2011, ISBN 978-0470746110;
- G. Kickelbick, Hybrid Materials: Synthesis, Characterisation and Applications, 2006, ISBN 978-3527312993;
- D. Vollath, Nanomaterials: An Introduction to Synthesis, Properties, and Applications, Wiley-VCH, 2013, 978-3527333790;
- M. Bertau, A. Müller, P. Fröhlich, M. Katzberg, Industrielle Anorg. Chemie, Wiley-VCH, 2013, ISBN 978-3527330195;

Assigned Courses:

Nachhaltige Chemie der Materialien und der Ressourcen – Reaktionen und Kreisläufe (lecture)

Übung: Nachhaltige Chemie der Materialien und der Ressourcen – Reaktionen und Kreisläufe (exercise course)

Examination

Nachhaltige Chemie der Materialien und Ressourcen - Reaktionen und Kreisläufe

written exam / length of examination: 90 minutes

Parts of the Module

Part of the Module: Übung zu Nachhaltige Chemie der Materialien und Ressourcen - Reaktionen und Kreisläufe

Mode of Instruction: exercise course

Language: English / German

Contact Hours: 2

Assigned Courses:

Nachhaltige Chemie der Materialien und der Ressourcen – Reaktionen und Kreisläufe (lecture)

Übung: Nachhaltige Chemie der Materialien und der Ressourcen – Reaktionen und Kreisläufe (exercise course)

Module MRM-0112: Finite element modeling of multiphysics phenomena <i>Finite-Elemente-Modellierung von Multiphysik-Phänomenen</i>		6 ECTS/LP
Version 2.9.0 (since WS19/20) Person responsible for module: Prof. Dr. Markus Sause Dozenten: Prof. Dr. Sause / Prof. Dr Peter		
Learning Outcomes / Competences: The students <ul style="list-style-type: none"> • get to know existing numerical methods for modeling and simulation of physical processes and systems • Learn the use and application of numerical methods for realistic problems • Are able to apply basic functional principles of a FEM program by using "COMSOL Multiphysics". 		
Remarks: This module is offered by faculty from MRM and Mathematics. It is intended for physics, MSE and WING students, who want to get an insight into a modern FEM program as it is used in academic and industrial applications.		
Workload: Total: 180 h		
Conditions: Recommended: MTH-6110 - Numerische Verfahren für Materialwissenschaftler, Physiker und Wirtschaftsingenieure		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Finite-Elemente-Modellierung von Multiphysik-Phänomenen		
Mode of Instruction: lecture Lecturers: Prof. Dr. Malte Peter, Prof. Dr. Markus Sause Language: German Contact Hours: 2		
Contents: The following content will be presented: <ul style="list-style-type: none"> • Modeling and simulation of physical processes and systems. • Basic concepts of FEM programs • Generation of meshes • Optimization strategies • Selection of solver algorithms • Example applications from electrodynamics • Example applications from thermodynamics • Example applications from continuum mechanics • Example applications from fluid dynamics • Coupling of differential equations for the solution of multiphysics phenomena 		
Lehr-/Lernmethoden: Slide presentation, classroom discussion		

Literature:

- Grossmann, C., Roos, H.-G., & Stynes, M. (2007). Numerical Treatment of Partial Differential Equations. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-540-71584-9>
- Eck, C., Garcke, H., & Knabner, P. (2017). Mathematische Modellierung. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-662-54335-1>
- Temam, R., & Miranville, A. (2005). Mathematical Modeling in Continuum Mechanics. Cambridge: Cambridge University Press.

Examination

Finite-Elemente-Modellierung von Multiphysik-Phänomenen

written/oral exam / length of examination: 60 minutes

Parts of the Module

Part of the Module: Übung zu Finite-Elemente-Modellierung von Multiphysik-Phänomenen

Mode of Instruction: exercise course

Language: German

Contact Hours: 2

Lehr-/Lernmethoden:

Independent reflection of topics to deepen the lecture content

Module MRM-0126: Ceramic Matrix Composites <i>Keramische Faserverbundwerkstoffe</i>		6 ECTS/LP
Version 3.0.0 (since WS21/22) Person responsible for module: Prof. Dr.-Ing. Dietmar Koch		
Contents: <ul style="list-style-type: none"> • Introduction in ceramic matrix composites • Basics of processing of technical ceramics • Processing chain of ceramic matrix composites (CMC) from raw materials to product • Processing and properties of ceramic fibers • Principal mechanisms of reinforcement in CMC • Properties of CMC • Application of CMC 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students know the basic concepts of mechanical behavior of ceramic matrix composites • The students have the competence to explain processing of ceramic fibers and ceramic matrix composites and describe their specific properties • The students know the Weibull statistics which describe the fiber strength distribution • The students know how to describe mechanical interactions between fiber and matrix • The students get the knowledge of application of ceramic matrix composites and are able to choose the according material for specific application. • The students acquire scientific skills to search for scientific literature and to evaluate scientific content 		
Workload: Total: 180 h 120 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Recommended: basic knowledge of materials		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Keramische Faserverbundwerkstoffe		
Mode of Instruction: lecture		
Language: English		
Contact Hours: 3		
Learning Outcome: see description of module		
Contents: see description of module		

Literature:

- N.P. Bansal, J. Lamon, Ceramic Matrix Composites: Materials, Modeling and Technology. John Wiley & Sons, Inc., 2015.
- W. Krenkel, Ceramic Matrix Composites. Wiley-VCH Verlag GmbH & Co. KGaA, 2008.
- K. K. Chawla, Composite Materials 3rd ed., Springer, 2012
- T. Ohji, M. Singh, Engineered Ceramics: Current Status and Future Prospects, ISBN: 978-1-119-10042-3, 2015

Assigned Courses:

Keramische Faserverbundwerkstoffe (lecture)

Examination

Keramische Faserverbundwerkstoffe

written exam, written exam / length of examination: 60 minutes

Parts of the Module

Part of the Module: Übung Keramische Faserverbundwerkstoffe

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Learning Outcome:

see description of module

Contents:

see description of module

Literature:

see description of module

Assigned Courses:

Keramische Faserverbundwerkstoffe (lecture)

Module MRM-0128: Bioinspired Composites <i>Bioinspired Composites</i>		6 ECTS/LP
Version 2.0.0 (since WS20/21) Person responsible for module: Prof. Dr.-Ing. Dietmar Koch		
Contents: <ul style="list-style-type: none"> • Introduction in bionics and bioinspiration • Basics of bionic principles • Fundamental approaches to develop technical components based on bioinspired ideas • Topology optimization • Bioinspired ceramic and polymer based components • Natural fiber based bioinspired materials • Application of bioinspired materials 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students know the basic principles of bionics and bioinspiration • The students know the bionically motivated development of technical components • The students have the competence to explain topology optimization • The students understand general principles bioinspired composites • The students get the knowledge about manufacturing, properties and application of natural fiber based composites • The students acquire scientific skills to search for scientific literature and to evaluate scientific content 		
Workload: Total: 180 h 120 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance)		
Conditions: basic knowledge of material science		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Bioinspired Composites Mode of Instruction: lecture Lecturers: Prof. Dr.-Ing. Dietmar Koch Language: English / German Frequency: each summer semester Contact Hours: 3		
Contents: see description of module		

Literature:

- B. Arnold, Werkstofftechnik für Wirtschaftsingenieure. 1. Auflage, Springer Verlag (2013)
- W. Bobeth (Ed.), Textile Faserstoffe - Beschaffenheit und Eigenschaft, Springer-Verlag (1993)
- W. Nachtigal, K. G. Blüchel, Das große Buch der Bionik – Neue Technologien nach dem Vorbild der Natur. 2. Auflage, Deutsche Verlags-Anstalt (2001)
- C. Hamm (Ed.), Evolution of Light Weight Structures - Analyses and Technical Applications, Springer-Verlag (2015)
- J. Müssig (Ed.), C. V. Stevens (Series Ed.), Industrial Applications of Natural Fibres: Structure, Properties and Technical Applications, Wiley Series in Renewable Resources (2010)

Examination

Bioinspired Composites

written exam, written exam / length of examination: 60 minutes

Parts of the Module

Part of the Module: Übung Bioinspired Composites

Mode of Instruction: exercise course

Language: German

Frequency: each summer semester

Contact Hours: 1

Learning Outcome:

see description of module

Contents:

see description of module

Literature:

see description of module

Module MRM-0136: Mechanical Characterization of Materials <i>Mechanical Characterization of Materials</i>		6 ECTS/LP
Version 1.1.0 (since SoSe21) Person responsible for module: Prof. Dr. Markus Sause		
Contents: The following topics are presented: <ul style="list-style-type: none"> • Introduction to material characterization • Linear material behaviour • Non-linear material behaviour • Material failure • Measurement technologies • Tensile testing • Compression testing • Shear testing • Other static testing concepts • Fracture mechanics • Assembly testing • Surface mechanics • Creep testing • Fatigue testing • High-Velocity testing • Component testing 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • Acquire knowledge in the field of materials testing and evaluation of materials. • Are introduced to important concepts in measurement techniques, and material models. • Are able to independently acquire further knowledge of the scientific topic using various forms of information. 		
Workload: Total: 180 h 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 60 h lecture and exercise course (attendance)		
Conditions: None		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Mechanical Characterization of Materials Mode of Instruction: lecture Language: English Contact Hours: 3		

Literature:

- Issler, L., & Häfele, H. R. P. (2003). Festigkeitslehre — Grundlagen. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-540-73485-7>
- Dowling, N. E. (2019). Mechanical Behavior of Materials (4th ed.). Pearson.
- Gross, D., & Seelig, T. (2011). Fracture Mechanics. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-642-19240-1>
- J. Schijve. (2008). Fatigue of Structures and Materials (2nd Edition). Springer Science & Business Media.
- Sadd, M. H. (2018). Continuum Mechanics Modeling of Material Behavior. In Continuum Mechanics Modeling of Material Behavior. Elsevier. <https://doi.org/10.1016/C2016-0-01495-X>

Examination

Mechanical Characterization of Materials

written exam, written exam / length of examination: 90 minutes

Parts of the Module

Part of the Module: Mechanical Characterization of Materials (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Module MRM-0142: Complex 3D Structures and Components from 2D Materials <i>Complex 3D Structures and Components from 2D Materials</i>	6 ECTS/LP
Version 1.0.0 Person responsible for module: Prof. Dr.-Ing. Suelen Barg	
Contents: Introduction: <ul style="list-style-type: none"> • Complex Materials in Nature • Motivations in assembling 2D Materials in 3D with an overview of their demands for future technological applications (from energy to aerospace) Nano and 2D Materials: <ul style="list-style-type: none"> • Introduction to nano and 2D Materials • Scaling laws and the evolution of properties with size • Graphene structure, properties, and characterization • 2D Transition Metal Carbides (MXenes) • 2D Materials synthesis routes: top-down and bottom-up approaches From 2D to 3D: <ul style="list-style-type: none"> • Motivations, Challenges, and opportunities • Colloidal processing routes with 2D Materials: Principles of wet processing • Self-assembly, templating, and additive manufacturing (AM) routes • Extrusion-based AM with 2D Materials • Functionalities and Applications • Aerogel supports for functional composite development • 3D architectures for energy storage 	
Learning Outcomes / Competences: By completing this unit, the students should be able to: Knowledge and understanding: <ul style="list-style-type: none"> • Define the classes of nanomaterials depending on their dimensionality. • Identify the different families of 2D materials beyond graphene, including transition metal dichalcogenides (TMDs), carbides and/or nitrides (MXenes). • Summarize top-down and bottom-up synthesis strategies towards 2D materials. • Select appropriate syntheses routes for a given application based on property requirements and cost efficiency of the approach. • Explain the basic principles, advantages and disadvantages of innovative colloidal processing routes applied to 2D materials-based 3D structures. Intellectual skills: <ul style="list-style-type: none"> • Solve problems involving the evolution of properties with size in nanomaterials by the application of simple spherical cluster approximation models. • Evaluate the effect of microstructure and composition to develop new materials properties and/or control device efficiency using real examples from the literature. Transferable and practical skills: <ul style="list-style-type: none"> • Evaluate English language scientific content in the specialist literature. • Apply analytical methods to solve problems. 	
Workload: Total: 180 h	

Conditions: materials science basic knowledge		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Complex 3D Structures and Components from 2D Materials		
Mode of Instruction: lecture		
Lecturers: Prof. Dr.-Ing. Suelen Barg		
Language: English		
Contact Hours: 4		
Learning Outcome: See description of the module		
Contents: See description of the module		
Literature: <ul style="list-style-type: none"> • Sulabha K Kulkarni, Nanotechnology: principles and Practice, 3rd Ed., 2015 (Springer-Verlag GmbH). • Leonard W. T. Ng, Guohua Hu, Richard C. T. Howe, Xiaoxi Zhu, Zongyin Yang, Printing of Graphene and Related 2D Materials, in: Technology, Formulation and Applications. 1st ed., 2019, (Springer-Verlag GmbH) • Research papers presented in class 		
Examination		
Complex 3D Structures and Components from 2D Materials written exam, written exam / length of examination: 1 hours		

Module PHM-0048: Physics and Technology of Semiconductor Devices <i>Physics and Technology of Semiconductor Devices</i>		6 ECTS/LP
Version 1.0.0 (since WS09/10) Person responsible for module: apl. Prof. Dr. Helmut Karl		
Contents: 1. Basic properties of semiconductors (electronic bandstructure, doping, carrier excitations and carrier transport) 2. Semiconductor diodes and transistors 3. Semiconductor technology		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • Basic knowledge of solid-state and semiconductor physics such as electronic bandstructure, doping, carrier excitations, and carrier transport. • Application of developed concepts (effective mass, quasi-Fermi levels) to describe the basic properties of semiconductors. • Application of these concepts to describe and understand the operation principles of semiconductor devices such as diodes and transistors • Knowledge of the technologically relevant methods and tools in semiconductor micro- and nanofabrication. • Integrated acquisition of soft skills: autonomous working with specialist literature in English, acquisition of presentation techniques, capacity for teamwork, ability to document experimental results, and interdisciplinary thinking and working. 		
Workload: Total: 180 h 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study) 60 h lecture and exercise course (attendance)		
Conditions: recommended prerequisites: basic knowledge in solid state physics, statistical physics and quantum mechanics.		
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Physics and Technology of Semiconductor Devices Mode of Instruction: lecture Language: English Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- Yu und Cardona: Fundamentals of Semiconductors (Springer)
- Sze: Physics of Semiconductor Devices (Wiley)
- Sze: Semiconductor Devices (Wiley)
- Madelung: Halbleiterphysik (Springer)
- Singh: Electronic and Optoelectronic Properties of Semiconductor Structures (Cambridge University Press)

Part of the Module: [Physics and Technology of Semiconductor Devices \(Tutorial\)](#)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Contents:

see module description

Examination

Physics and Technology of Semiconductor Devices

written exam / length of examination: 90 minutes

Examination Prerequisites:

Physics and Technology of Semiconductor Devices

Module PHM-0049: Nanostructures / Nanophysics <i>Nanostructures / Nanophysics</i>		6 ECTS/LP
Version 1.2.0 (since WS09/10) Person responsible for module: Prof. Dr. István Kézsmárki		
Contents: <ol style="list-style-type: none"> 1. Semiconductor quantum wells, wires and dots, low dimensional electron systems 2. Magnetotransport in low-dimensional systems, Quantum-Hall-Effect, Quantized conductance 3. Optical properties of nanostructures and their application in modern optoelectronic devices, Nanophotonics 4. Fabrication and detection techniques of nanostructures 5. Ferroic properties of nanostructures (Ferroelectricity, Magnetism, Multiferroicity) 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students gain basic knowledge of the fundamental concepts in modern nanoscale science. • The students have detailed knowledge of low-dimensional semiconductor structures and how these systems can be applied for novel functional devices for high-frequency electronics and optoelectronics • The students gain competence in selecting different fabrication and characterization approaches for specific nanostructures. • The students are able apply these concepts to tackle present problems in nanophysics. • The students acquire scientific skills to search for scientific literature and to evaluate scientific content. 		
Workload: Total: 180 h 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study)		
Conditions: recommended prerequisites: basic knowledge in solid-state physics and quantum mechanics.		
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Nanostructures / Nanophysics Mode of Instruction: lecture Language: English Contact Hours: 4		
Learning Outcome: see module description		
Contents: see module description		
Literature: <ul style="list-style-type: none"> • Yu und Cardona: Fundamentals of Semiconductors • Singh: Electronic and Optoelectronic Properties of Semiconductor Structures (Cambridge University Press) • Davies: The Physics of low-dimensional Semiconductors (Cambridge University Press) 		

Examination

Nanostructures / Nanophysics

oral exam / length of examination: 30 minutes

Examination Prerequisites:

Nanostructures / Nanophysics

Module PHM-0052: Solid State Spectroscopy with Synchrotron Radiation and Neutrons <i>Solid State Spectroscopy with Synchrotron Radiation and Neutrons</i>		6 ECTS/LP
Version 1.2.0 (since WS09/10) Person responsible for module: Prof. Dr. Christine Kuntscher		
Contents: <ol style="list-style-type: none"> 1. Electromagnetic radiation: description, generation, detection [5] 2. Spectral analysis of electromagnetic radiation: monochromators, spectrometer, interferometer [2] 3. Excitations in the solid state: Dielectric function [2] 4. Infrared spectroscopy 5. Ellipsometry 6. Photoemission spectroscopy 7. X-ray absorption spectroscopy 8. Neutrons: Sources, detectors 9. Neutron scattering 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basics of spectroscopy and important instrumentation and methods, • have acquired the skills of formulating a mathematical-physical ansatz in spectroscopy and can apply these in the field of solid state spectroscopy, • have the competence to deal with current problems in solid state spectroscopy autonomously, and are able to judge proper measurement methods for application. • Integrated acquirement of soft skills. 		
Workload: Total: 180 h 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: basic knowledge in solid-state physics		
Frequency: annually	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Solid State Spectroscopy with Synchrotron Radiation and Neutrons Mode of Instruction: lecture Language: English Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- H. Kuzmany, Solid State Spectroscopy (Springer)
- N. W. Ashcroft, N. D. Mermin, Solid State Physics (Holt, Rinehart and Winston)
- J. M. Hollas, Modern Spectroscopy

Part of the Module: Solid State Spectroscopy with Synchrotron Radiation and Neutrons (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Solid State Spectroscopy with Synchrotron Radiation and Neutrons

oral exam / length of examination: 30 minutes

Examination Prerequisites:

Solid State Spectroscopy with Synchrotron Radiation and Neutrons

Module PHM-0056: Ion-Solid Interaction <i>Ion-Solid Interaction</i>		6 ECTS/LP
Version 1.0.0 (since WS09/10) Person responsible for module: apl. Prof. Dr. Helmut Karl		
Contents: <ul style="list-style-type: none"> • Introduction (areas of scientific and technological application, principles) • Fundamentals of atomic collision processes (scattering, cross-sections, energy loss models, potentials in binary collision models) • Ion-induced modification of solids (integrated circuit fabrication with emphasis on ion induced phenomena, ion implantation, radiation damage, ion milling and etching (RIE), sputtering, erosion, deposition) • Transport phenomena • Analysis with ion beams 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the physical principles and the basic mechanisms of the interaction between particles and solid state bodies in the energy range of eV to MeV, • are able to choose adequate physical models for specific technological and scientific applications, and • have the competence to work extensively autonomous on problems concerning the interaction between ions and solid state bodies. • Integrated acquirement of soft skills. 		
Workload: Total: 180 h 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study) 80 h studying of course content through exercises / case studies (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Basic Courses in Physics I–IV, Solid State Physics, Nuclear Physics		
Frequency: annually	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Ion-Solid Interaction Mode of Instruction: lecture Language: English Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- R. Smith, Atomic and ion collisions in solids and at surfaces (Cambridge University Press, 1997)
- E. Rimini, Ion implantation: Basics to device fabrication (Kluwer, 1995)
- W. Eckstein: Computer Simulation of Ion-Solid Interactions (Springer, 1991)
- H. Ryssel, I. Ruge: Ionenimplantation (Teubner, 1978)
- Y. H. Ohtsuki: Charged Beam Interaction with Solids (Taylor & Francis, 1983)
- J. F. Ziegler (Hrsg.): The Stopping and Range of Ions in Solids (Pergamon)
- R. Behrisch (Hrsg.): Sputtering by Particle Bombardment (Springer)
- M. Nastasi, J. K. Hirvonen, J. W. Mayer: Ion-Solid Interactions: Fundamentals and Applications (Cambridge University Press, 1996)
- <http://www.SRIM.org>

Part of the Module: Ion-Solid Interaction (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Ion-Solid Interaction

written exam / length of examination: 90 minutes

Examination Prerequisites:

Ion-Solid Interaction

Module PHM-0057: Physics of Thin Films <i>Physics of Thin Films</i>		6 ECTS/LP
Version 1.6.0 (since WS09/10) Person responsible for module: PD Dr. German Hammerl		
Contents: <ul style="list-style-type: none"> Thin film growth: basics, thermodynamic considerations, surface kinetics, growth mechanisms Thin film growth techniques: vacuum technology, physical vapor deposition, chemical vapor deposition Analysis and characterization of thin films: in-sit methods, ex-situ methods, direct methods Properties and applications of thin films 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> know a broad spectrum of methods of thin film technology and material properties and applications of thin films, have the competence to deal with current problems in the field of thin film technology largely autonomous, are able to choose the right substrates and thin film materials for epitaxial thin film growth to achieve desired application conditions, acquire skills of combining the various technologies for growing thin layers with respect to their properties and applications, and acquire scientific soft skills to search for scientific literature, understand technical english, work with literature in the field of thin films, interpret experimental results. 		
Workload: Total: 180 h 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study)		
Conditions: none		
Frequency: each winter semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Physics of Thin Films Mode of Instruction: lecture Language: English Contact Hours: 4		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- H. Frey, G. Kienel, Dünnschichttechnologie (VDI Verlag, 1987)
- H. Lüth, Solid Surfaces, Interfaces and Thin Films (Springer Verlag, 2001)
- A. Wagendristel, Y. Wang, An Introduction to Physics and Technology of Thin Films (World Scientific Publishing, 1994)
- M. Ohring, The Materials Science of Thin Films (Academic Press, 1992)

Examination

Physics of Thin Films

written exam / length of examination: 90 minutes

Examination Prerequisites:

Physics of Thin Films

Module PHM-0058: Organic Semiconductors <i>Organic Semiconductors</i>		6 ECTS/LP
Version 1.3.0 (since WS09/10) Person responsible for module: Prof. Dr. Wolfgang Brütting		
Contents: Basic concepts and applications of organic semiconductors Introduction <ul style="list-style-type: none"> • Materials and preparation • Structural properties • Electronic structure • Optical and electrical properties Devices and Applications <ul style="list-style-type: none"> • Organic metals • Light-emitting diodes • Solar cells • Field-effect transistors 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic structural and electronic properties of organic semiconductors as well as the essential function of organic semiconductor devices, • have acquired skills for the classification of the materials taking into account their specific features in the functioning of components, • and have the competence to comprehend and attend to current problems in the field of organic electronics. • Integrated acquirement of soft skills: practicing technical English, working with English specialist literature, ability to interpret experimental results 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 40 h studying of course content through exercises / case studies (self-study) 40 h studying of course content using provided materials (self-study) 40 h studying of course content using literature (self-study)		
Conditions: It is strongly recommended to complete the module solid-state physics first. In addition, knowledge of molecular physics is desired.		
Frequency: annually	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Organic Semiconductors Mode of Instruction: lecture Language: English Contact Hours: 3		

Learning Outcome:

see module description

Contents:

see module description

Literature:

- M. Schwoerer, H. Ch. Wolf: Organic Molecular Solids (Wiley-VCH)
- W. Brütting: Physics of Organic Semiconductors (Wiley-VCH)
- A. Köhler, H. Bässler: Electronic Processes in Organic Semiconductors (Wiley-VCH)
- S.R. Forrest: Organic Electronics (Oxford Univ. Press)

Part of the Module: Organic Semiconductors (Tutorial)

Mode of Instruction: exercise course

Language: English

Frequency: every 3rd semester

Contact Hours: 1

Examination**Organic Semiconductors**

written exam / length of examination: 90 minutes

Examination Prerequisites:

Organic Semiconductors

Module PHM-0059: Magnetism <i>Magnetism</i>		6 ECTS/LP
Version 1.0.0 (since WS09/10) Person responsible for module: Dr. Hans-Albrecht Krug von Nidda		
Contents: <ul style="list-style-type: none"> • History, basics • Magnetic moments, classical and quantum phenomenology • Exchange interaction and mean-field theory • Magnetic anisotropy and magnetoelastic effects • Thermodynamics of magnetic systems and applications • Magnetic domains and domain walls • Magnetization processes and micro magnetic treatment • AC susceptibility and ESR • Spintransport / spintronics • Recent problems of magnetism 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic properties and phenomena of magnetic materials and the most important methods and concepts for their description, like mean-field theory, exchange interactions and micro magnetic models, • have the ability to classify different magnetic phenomena and to apply the corresponding models for their interpretation, and • have the competence independently to treat fundamental and typical topics and problems of magnetism. • Integrated acquirement of soft skills. 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study)		
Conditions: basics of solid-state physics and quantum mechanics		
Frequency: annually	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Magnetism		
Mode of Instruction: lecture		
Language: English		
Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- D. H. Martin, Magnetism in Solids (London Iliffe Books Ltd.)
- J. B. Goodenough, Magnetism and the Chemical Bond (Wiley)
- P. A. Cox, Transition Metal Oxides (Oxford University Press)
- C. Kittel, Solid State Physics (Wiley)
- D. C. Mattis, The Theory of Magnetism (Wiley)
- G. L. Squires, Thermal Neutron Scattering (Dover Publications Inc.)

Part of the Module: Magnetism (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Magnetism

written exam / length of examination: 90 minutes

Examination Prerequisites:

Magnetism

Module PHM-0060: Low Temperature Physics <i>Low Temperature Physics</i>		6 ECTS/LP
Version 1.1.0 (since WS09/10) Person responsible for module: Prof. Dr. Philipp Gegenwart		
Contents: <ul style="list-style-type: none"> • Introduction • Properties of matter at low temperatures • Cryoliquids and superfluidity • Cryogenic engineering • Thermometry • Quantum transport, criticality and entanglement in matter 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic properties of matter at low temperatures and the corresponding experimental techniques, • have acquired the theoretical knowledge to perform low-temperature measurements, • and know how to experimentally investigate current problems in low-temperature physics. 		
Workload: Total: 180 h 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 60 h lecture and exercise course (attendance) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: Physik IV - Solid-state physics		
Frequency: every 3rd semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Low Temperature Physics Mode of Instruction: lecture Language: English Contact Hours: 3		
Learning Outcome: see module description		

Contents:

- Introduction (temperature scale, history of low temperature physics)
- Properties of matter at low temperatures (specific heat, thermal expansion, electrical resistance, thermal conductivity)
- Cryoliquids and superfluidity (nitrogen, hydrogen, 4-He and 3-He: phase diagrams, superfluidity)
- Cryogenic engineering (liquefaction of gases, helium cryostats, dilution refrigerator, adiabatic demagnetization, further techniques)
- Thermometry (primary and secondary thermometers at different temperature regimes)
- Quantum Matter (quantum Transport, Quantum phase transitions, Quantum spin liquids)

Literature:

C. Enss, S. Hunklinger, Tieftemperaturphysik (Springer)
F. Pobell, Matter and Methods at Low Temperatures (Springer)

Part of the Module: Low Temperature Physics (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Low Temperature Physics

oral exam / length of examination: 30 minutes

Examination Prerequisites:

Low Temperature Physics

Module PHM-0066: Superconductivity <i>Superconductivity</i>		6 ECTS/LP
Version 1.0.0 (since WS11/12) Person responsible for module: Prof. Dr. Philipp Gegenwart		
Contents: <ul style="list-style-type: none"> • Introductory Remarks and Literature • History and Main Properties of the Superconducting State, an Overview • Phenomenological Thermodynamics and Electrodynamics of the SC • Ginzburg-Landau Theory • Microscopic Theories • Fundamental Experiments on the Nature of the Superconducting State • Josephson-Effects • High Temperature Superconductors • Application of Superconductivity 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • will get an introduction to superconductivity, • by a presentation of experimental results they will learn the fundamental properties of the superconducting state, • are informed about the most important technical applications of superconductivity. • Special attention will be drawn to the basic concepts of the main phenomeno-logical and microscopic theories of the superconducting state, to explain the experimental observations. • For self-studies a comprehensive list of further reading will be supplied. 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study)		
Conditions: <ul style="list-style-type: none"> • Physik IV – Solid-state physics • Theoretical physics I-III 		
Frequency: every 3rd semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Superconductivity Mode of Instruction: lecture Language: English Contact Hours: 4		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- W. Buckel, Supraleitung, 5. Auflage (VCH, Weinheim, 1994)
- W. Buckel und R. Kleiner, Supraleitung, 6. Auflage (WILEY-VCH, Weinheim, 2004)
- M. Tinkham, Introduction to Superconductivity, 2nd Edition (McGraw-Hill, Inc., New York, 1996, Reprint by Dover Publications Inc. Miniola , 2004)
- Weitere Literatur wird in der Vorlesung angegeben

Assigned Courses:

Superconductivity (lecture)

Examination

Superconductivity

oral exam / length of examination: 30 minutes

Examination Prerequisites:

Superconductivity

Module PHM-0068: Spintronics <i>Spintronics</i>		6 ECTS/LP
Version 1.6.0 (since SoSe14) Person responsible for module: PD Dr. German Hammerl		
Contents: <ul style="list-style-type: none"> • Basic micromagnetic interactions (exchange, anisotropy, DMI, stray fields, external fields) and where they come from • Emergence of spin textures such as domain walls and bubbles/skyrmions • Torques acting on the local magnetization (magnetic field torque, current in-plane spin-transfer torque, spin-Hall effect and spin-orbit torques) • Switching • Motion of spin textures, 1D model and Thiele equation • Magneto-resistance and Hall effects and their utility in electrical readout • Ultrafast effects • Device applications • Experimental techniques in the field of spintronics 		
Learning Outcomes / Competences: The students: The students: <ul style="list-style-type: none"> • know the fundamental interactions in magnetic materials, the basic spintronic effects, and the related device structures, • have the competence to deal with current problems in the field of spintronics largely autonomously, • are able to choose materials in order to achieve demanding properties in spintronic applications, • are able to design device components to achieve spin polarization, • acquire scientific skills in finding and understanding current literature dealing with spintronic devices and applications, identifying suitable materials and material combinations with respect to their applicability for spintronic devices. 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study)		
Conditions: none		
Frequency: each summer semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Spintronics Mode of Instruction: lecture Language: English Contact Hours: 3		

Learning Outcome:

see module description

Contents:

see module description

Literature:

- N. W. Ashcroft, N. D. Mermin, Solid State Physics, Cengage Learning (2011), ISBN: 81-315-0052-7
- C. Felser, G. H. Hechter, Spintronics - From Materials to Devices, Springer (2013), ISBN: 978-90-481-3831-9
- S. Bandyopadhyay, M. Cahay, Introduction to Spintronics, CRC Press (2008), ISBN: 978-0-9493-3133-6

Part of the Module: Spintronics (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Spintronics

written exam / length of examination: 90 minutes

Examination Prerequisites:

Spintronics

Module PHM-0069: Applied Magnetic Materials and Methods <i>Applied Magnetic Materials and Methods</i>		6 ECTS/LP
Version 1.1.0 (since WS14/15) Person responsible for module: Prof. Dr. Manfred Albrecht		
Contents: <ul style="list-style-type: none"> • Basics of magnetism • Ferrimagnets, permanent magnets • Magnetic nanoparticles • Superparamagnetism • Exchange bias effect • Magnetoresistance, sensors • Experimental methods (e.g. Mößbauer Spectroscopy, mu-SR) 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students know the basic terms and concepts of magnetism, • get a profound understanding of basic physical relations and their applications, • acquire the ability to describe qualitative observations, interpret quantitative measurements, and develop mathematical descriptions of physical effects of chosen magnetic material systems. • Integrated acquirement of soft skills: autonomous working with specialist literature in English, acquisition of presentation techniques, capacity for teamwork, ability to document experimental results, and interdisciplinary thinking and working. 		
Workload: Total: 180 h 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Basics in solid state physics		
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Applied Magnetic Materials and Methods		
Mode of Instruction: lecture		
Language: English		
Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		
Literature: Stephan Bundell, Magnetism in Condensed Matter, Oxford University Press, ISBN: 0-19-850591-4 (Pbk) J.M.C. Coey, Magnetism and Magnetic Materials, Cambridge University Press, ISBN: 978-0-521-81614-4 (hardback)		

Part of the Module: Applied Magnetic Materials and Methods (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Applied Magnetic Materials and Methods

oral exam / length of examination: 30 minutes

Examination Prerequisites:

Applied Magnetic Materials and Methods

Module PHM-0122: Non-Destructive Testing <i>Non-Destructive Testing</i>		6 ECTS/LP
Version 1.0.0 (since WS14/15) Person responsible for module: Prof. Dr. Markus Sause		
Contents: <ul style="list-style-type: none"> • Introduction to nondestructive testing methods • Visual inspection • Ultrasonic testing • Guided wave testing • Acoustic emission analysis • Thermography • Radiography • Eddy current testing • Specialized nondestructive methods 		
Learning Outcomes / Competences: The students <ul style="list-style-type: none"> • acquire knowledge in the field of nondestructive evaluation of materials, • are introduced to important concepts in nondestructive measurement techniques, • are able to independently acquire further knowledge of the scientific topic using various forms of information. • Integrated acquirement of soft skills 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: Basic knowledge on materials science, in particular composite materials		
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Non-Destructive Testing		
Mode of Instruction: lecture		
Language: English		
Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- Raj: Practical Non-destructive Testing
- Shull: Nondestructive Evaluation - Theory and Applications
- Krautkrämer: Ultrasonic testing of materials
- Grosse: Acoustic Emission Testing
- Rose: Ultrasonic waves in solid media
- Maldague: Nondestructive Evaluation of Materials by Infrared Thermography
- Herman: Fundamentals of Computerized Tomography

Further literature - actual scientific papers and reviews - will be announced at the beginning of the lecture.

Assigned Courses:

Non-Destructive Testing (lecture)

Part of the Module: Non-Destructive Testing (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Assigned Courses:

Non-Destructive Testing (Tutorial) (exercise course)

Examination

Non-Destructive Testing

written exam / length of examination: 90 minutes

Examination Prerequisites:

Non-Destructive Testing

Module PHM-0163: Fiber Reinforced Composites: Processing and Materials Properties <i>Fiber Reinforced Composites: Processing and Materials Properties</i>		6 ECTS/LP
Version 1.2.0 (since SoSe15) Person responsible for module: Dr. Judith Moosburger-Will		
Contents: <ul style="list-style-type: none"> • Production of fibers (e.g. glass, carbon, or ceramic fibers) • Physical and chemical properties of fibers and their precursor materials • Physical and chemical properties of commonly used polymeric and ceramic matrix materials • Semi-finished products • Composite production technologies • Application of fiber reinforced materials 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the physical and chemical properties of fibers, matrices, and fiber-reinforced materials. • know the basics of production technologies of fibers, polymeric, ceramic matrices, and fiber-reinforced materials. • know the application areas of composite materials. • have the competence to explain material properties of fibers, matrices, and composites. • have the competence to choose the right materials according to application relevant conditions. • are able to independently acquire further knowledge of the scientific topic using various forms of information. 		
Remarks: ELECTIVE COMPULSORY MODULE		
Workload: Total: 180 h 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Recommended: basic knowledge in materials science, basic lectures in organic chemistry		
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Fiber Reinforced Composites: Processing and Materials Properties Mode of Instruction: lecture Language: English Contact Hours: 3		

Literature:

- Morgan: Carbon fibers and their composites
- Ehrenstein: Polymeric materials
- Krenkel: Ceramic Matrix Composites
- Henning, Moeller: Handbuch Leichtbau
- Schürmann: Konstruieren mit Faser-Kunststoff-Verbunden
- Neitzel, Mitschang: Handbuch Verbundwerkstoffe

Further literature - actual scientific papers and reviews - will be announced at the beginning of the lecture.

Assigned Courses:

Fiber Reinforced Composites: Processing and Materials Properties (lecture)

Part of the Module: Fiber Reinforced Composites: Processing and Materials Properties (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Literature:

see lecture

Assigned Courses:

Fiber Reinforced Composites: Processing and Materials Properties (Tutorial) (exercise course)

Examination

Fiber Reinforced Composites: Processing and Materials Properties

written exam / length of examination: 90 minutes

Examination Prerequisites:

Fiber Reinforced Composites: Processing and Materials Properties

Module PHM-0167: Oxidation and Corrosion <i>Oxidation and Corrosion</i>	6 ECTS/LP
Version 1.0.0 (since SoSe15) Person responsible for module: Prof. Dr. Ferdinand Haider	
Contents: Introduction Review of thermodynamics Chemical equilibria Electrochemistry Electrode kinetics High temperature oxidation Localized corrosion <ul style="list-style-type: none"> • Shallow pit corrosion • Pitting corrosion • Crevice corrosion • Intercrystalline corrosion • Stress corrosion cracking • Fatigue corrosion • Erosion corrosion • Galvanic corrosion Water and seawater corrosion Corrosion monitoring Corrosion properties of specific materials Specific corrosion problems in certain branches <ul style="list-style-type: none"> • Oil and Gas industry • Automobile industry • Food industry Corrosion protection <ul style="list-style-type: none"> • Passive layers • Reaction layers (Diffusion layers ...) • Coatings (organic, inorganic) • Cathodic, anodic protection • Inhibitors 	
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the the fundamental basics, mechanics, types of corrosion processes and their electrochemical explanation • obtain the skill to understand typical electrochemical quantification of corrosion processes. • acquire the competence to assess corrosion phenomena from typical damage patterns 	
Remarks: Scheduled every second summer semester.	
Workload: Total: 180 h 60 h lecture and exercise course (attendance)	

120 h studying of course content using provided materials (self-study)		
Conditions: Recommended: good knowledge in materials science, basic knowledge in physical chemistry		Credit Requirements: written exam (90 min)
Frequency: each summer semester alternating with PHM-0168	Recommended Semester: from 3.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module**Part of the Module: Oxidation and Corrosion****Mode of Instruction:** lecture**Language:** English**Frequency:** each winter semester**Contact Hours:** 3**Literature:**

- Schütze: Corrosion and Environmental Degradation

Part of the Module: Oxidation and Corrosion (Tutorial)**Mode of Instruction:** exercise course**Language:** English**Frequency:** each winter semester**Contact Hours:** 1**Examination****Oxidation and Corrosion**

written exam / length of examination: 90 minutes

Examination Prerequisites:

Oxidation and Corrosion

Module PHM-0168: Modern Metallic Materials <i>Modern Metallic Materials</i>		6 ECTS/LP
Version 1.0.0 (since SoSe15) Person responsible for module: Prof. Dr. Ferdinand Haider		
Contents: Introduction Review of physical metallurgy Steels: <ul style="list-style-type: none"> • principles • common alloying elements • martensitic transformations • dual phase steels • TRIP and TWIP steels • maraging steel • electrical steel • production and processing Aluminium alloys: <ul style="list-style-type: none"> • 2xxx • 6xxx • 7xxx • Processing – creep forming, hydroforming, spinforming Titanium alloys Magnesium alloys Superalloys Intermetallics, high entropy alloys		
Learning Outcomes / Competences: Students <ul style="list-style-type: none"> • learn about relevant classes of actual metallic alloys and their properties • acquire the skill to derive alloy properties from physical metallurgy principles and concepts • have the competence to choose and to explain appropriate metallic materials for special applications 		
Remarks: Scheduled every second summer semester.		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: Recommended: Knowledge of physical metallurgy and physical chemistry		
Frequency: each summer semester alternating with PHM-0167	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module

Part of the Module: Modern Metallic Materials

Mode of Instruction: lecture

Language: English

Contact Hours: 4

Literature:

Cahn-Haasen-Kramer: Materials Science and Technology

Original literature

Examination

Modern Metallic Materials

written exam / length of examination: 90 minutes

Examination Prerequisites:

Modern Metallic Materials

Module PHM-0174: Theoretical Concepts and Simulation <i>Theoretical Concepts and Simulation</i>		6 ECTS/LP
Version 1.0.0 (since WS09/10) Person responsible for module: Prof. Dr. Liviu Chioncel		
Contents: <ol style="list-style-type: none"> 1. Introduction: operating systems, programming languages, data visualization tools 2. Basic numerical methods: interpolation, integration 3. Ordinary and Partial Differential Equations (e.g., diffusion equation, Schrödinger equation) 4. Molecular dynamics 5. Monte Carlo simulations 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the principal concepts of thermodynamics and statistical physics as well as the numerical methods relevant in material science, • are able to solve simple problems numerically. They are able to write the codes and to present the results, • have the expertise to find the numerical method appropriate for the given problem and to judge the quality and validity of the numerical results, • Integrated acquirement of soft skills: independent handling of hard- and software while using English documentations, ability to investigate abstract circumstances with the help of a computer and present the results in written and oral form, capacity for teamwork. 		
Remarks: Links to software related to the course: <ul style="list-style-type: none"> • http://www.bloodshed.net/ • http://www.cplusplus.com/doc/tutorial/ • http://www.cygwin.com/ • http://xmd.sourceforge.net/download.html • http://www.rasmol.org/ • http://felt.sourceforge.net/ 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study)		
Conditions: Recommended: basic knowledge of quantum mechanics, thermodynamics, and numerical methods as well as of a programming language		Credit Requirements: project work in small groups, including a written summary of the results (ca. 10-20 pages) as well as an oral presentation
Frequency: each summer semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Theoretical Concepts and Simulation Mode of Instruction: lecture Language: English Contact Hours: 3
Literature: <ul style="list-style-type: none">• Tao Pang, An Introduction to Computational Physics (Cambridge University Press)• J. M. Thijssen, Computational Physics (Cambridge University Press)• Koonin, Meredith, Computational Physics (Addison-Weseley)• D. C. Rapaport, The Art of Molecular Dynamics Simulation, (Cambridge University Press)• W. H. Press et al, Numerical Recipes (Cambridge University Press)
Part of the Module: Theoretical Concepts and Simulation (Project) Mode of Instruction: exercise course Language: English Contact Hours: 1
Examination Theoretical Concepts and Simulation seminar / length of examination: 30 minutes Examination Prerequisites: Theoretical Concepts and Simulation

Module PHM-0193: Plasma Material Interaction <i>Plasma-Material-Wechselwirkung</i>		6 ECTS/LP
Version 2.2.0 (since WS17/18) Person responsible for module: apl. Prof. Dr.-Ing. Ursel Fantz		
Contents: <ul style="list-style-type: none"> Fundamentals of plasma material interactions (winter term) High heat load components in nuclear fusion devices (summer term) 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> Knowledge: The students know the fundamental plasma material interaction processes and their implication for nuclear fusion research in light of the technological boundary conditions and challenges. Skills: The students are proficient in a differentiated analysis of complex systems, based on learning from examples of power exhaust in fusion devices. Competencies: The students are competent in elaborating current topics of plasma material interaction. Integrated achievement of key qualifications: Acquirement of interdisciplinary knowledge, independent work with English literature, abstraction and approximation of complex processes using numerical models, application-oriented thinking and ability to contemplate about experimental results. 		
Remarks: The two lectures of this module can be followed in an arbitrary order. Thus, the module can be started at a summer or winter term.		
Workload: Total: 180 h 60 h studying of course content using provided materials (self-study) 60 h studying of course content using literature (self-study) 60 h lecture (attendance)		
Conditions: recommended: module "Plasmaphysik und Fusionsforschung"		Credit Requirements: general examination for entire module
Frequency: annually	Recommended Semester: from 2.	Minimal Duration of the Module: 2 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Fundamentals of plasma material interactions Mode of Instruction: lecture Language: English Frequency: each winter semester Contact Hours: 2		
Learning Outcome: see description of module		
Contents: Fundamental plasma boundary physics, erosion processes: physical sputtering, chemical erosion, radiation induced sublimation, arcs, experimental observation of surface processes in plasmas, methods for characterizing surfaces, coating techniques, hydrogen retention, surface modification by plasmas.		

<p>Literature:</p> <ul style="list-style-type: none"> • P. Stangeby: The plasma boundary of magnetic fusion devices (IOP, 2000) • R. Clark, D. Reiter (Eds.): Nuclear Fusion Research, Understanding Plasma-Surface Interactions (Springer, 2005) • O. Auciello, D. L. Flamm (Eds.): Plasma Diagnostics, Volume 2: Surface Analysis and Interactions (Plasma-Materials Interactions) (Academic Press, 1989) • M. Turnyanskiy et al.: European roadmap to the realization of fusion energy: Mission for solution on heat-exhaust systems (Fusion Engineering and Design, 2015)
<p>Assigned Courses:</p> <p>Fundamentals of plasma material interactions (lecture)</p>
<p>Part of the Module: High heat load components in nuclear fusion devices</p> <p>Mode of Instruction: lecture</p> <p>Language: English</p> <p>Frequency: each summer semester</p> <p>Contact Hours: 2</p>
<p>Learning Outcome:</p> <p>see description of module</p>
<p>Contents:</p> <p>Interdependency of material choices and fusion performance, material choices and technologies for power exhaust in a fusion power plant, migration of materials in a fusion plasma, diagnostics for plasma material interaction in fusion devices (in situ and post mortem), numerical methods for studying plasma material interaction.</p>
<p>Literature:</p> <ul style="list-style-type: none"> • P. Stangeby: The plasma boundary of magnetic fusion devices (IOP, 2000) • R. Clark, D. Reiter (Eds.): Nuclear Fusion Research, Understanding Plasma-Surface Interactions (Springer, 2005) • M. Turnyanskiy et al.: European roadmap to the realization of fusion energy: Mission for solution on heat-exhaust systems, Fusion Engineering and Design (2015) • V. A. Evtikhin et al.: Lithium divertor concept and results of supporting experiments, Plasma Phys. Control. Fusion 44, 955 (2002) • T. Hirai et al.: ITER tungsten divertor design development and qualification program, Fusion Eng. Des. 88, 1798 (2013) • A. R. Raffray et al.: High heat flux components - Readiness to proceed from near term fusion systems to power plants, Fusion Eng. Des. 85, 93 (2010)
<p>Examination</p> <p>Plasma Material Interaction</p> <p>oral exam / length of examination: 30 minutes</p>

Module PHM-0203: Physics of Cells <i>Physics of Cells</i>		6 ECTS/LP
Version 1.3.0 (since SoSe22) Person responsible for module: Dr. Christoph Westerhausen		
Contents: <ul style="list-style-type: none"> Physical principles in Biology Cell components and their material properties: cell membrane, organelles, cytoskeleton Thermodynamics of proteins and biological membranes Physical methods and techniques for studying cells Cell adhesion – interplay of specific, universal and elastic forces Tensile strength and elasticity of tissue - macromolecules of the extra cellular matrix Micro mechanics and properties of the cell as a biomaterial Cell adhesion Cell migration Cell actuation, cell-computer-communication, and cell stimulation 		
Learning Outcomes / Competences: The students <ul style="list-style-type: none"> know basic physical properties of human cells, as building blocks of living organisms and their material properties. know the basic functionality of mechanical and optical methods to study living cells know physical descriptions of fundamental biological processes and properties of biomaterials. are able to express biophysical questions and define model systems to answer these questions. The students improve the key competences: <ul style="list-style-type: none"> self-dependent working with English specialist literature. processing of experimental data. interdisciplinary thinking and working. 		
Workload: 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: Mechanics, Thermodynamics		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Physics of Cells		
Mode of Instruction: lecture		
Language: English / German		
Contact Hours: 2		
Learning Outcome: see module description		

<p>Contents: see module description</p>
<p>Literature:</p> <ul style="list-style-type: none"> • Sackmann, Erich, and Rudolf Merkel. <i>Lehrbuch der Biophysik</i>. Wiley-VCH, 2010. • Heimburg, Thomas. <i>Thermal Biophysics of Membranes</i>. Wiley-VCH, 2007 • Nelson, Philip. <i>Biological physics</i>. New York: WH Freeman, 2004. • Boal, D. <i>Mechanics of the Cell</i>. Cambridge University Press, 2012 • Lecture notes
<p>Assigned Courses:</p> <p>Physics of Cells (lecture)</p>
<p>Part of the Module: Physics of Cells (Tutorial)</p> <p>Mode of Instruction: exercise course</p> <p>Language: English</p> <p>Contact Hours: 2</p>
<p>Learning Outcome: see module description</p>
<p>Contents: see module description</p>
<p>Literature: see module description</p>
<p>Assigned Courses:</p> <p>Physics of Cells (Tutorial) (exercise course)</p>
<p>Examination</p> <p>Physics of Cells oral exam / length of examination: 30 minutes</p>

Module PHM-0225: Analog Electronics for Physicists and Materials Scientists <i>Analog Electronics for Physicists and Materials Scientists</i>		6 ECTS/LP
Version 1.2.0 (since WS15/16) Person responsible for module: Andreas Hörner		
Contents: <ol style="list-style-type: none"> 1. Basics in electronic and electrical engineering 2. Quadrupole theory 3. Electronic Networks 4. Semiconductor Devices 5. Implementation of transistors 6. Operational amplifiers 7. Optoelectronic Devices 8. Measurement Devices 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic terms, concepts and phenomena of electronic and electrical engineering for the use in the Lab, • have skills in easy circuit design, measuring and control technology, analog electronics, • have expertise in independent working on circuit problems. They can calculate and develop easy circuits. 		
Workload: Total: 180 h 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study) 60 h lecture and exercise course (attendance)		
Conditions: none		
Frequency: each winter semester	Recommended Semester:	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Analog Electronics for Physicists and Materials Scientists Mode of Instruction: lecture + exercise Lecturers: Andreas Hörner Language: English Contact Hours: 4 ECTS Credits: 6.0		
Assigned Courses: Analog Electronics for Physicists and Materials Scientists (lecture + exercise)		
Examination Analog Electronics Analog Electronics for Physicists and Materials Scientists written exam / length of examination: 90 minutes Examination Prerequisites: Analog Electronics for Physicists and Materials Scientists		

Module PHM-0226: Digital Electronics for Physicists and Materials Scientists <i>Digital Electronics for Physicists and Materials Scientists</i>		6 ECTS/LP
Version 1.3.0 (since WS15/16) Person responsible for module: Andreas Hörner		
Contents: <ol style="list-style-type: none"> 1. Boolean algebra and logic gates 2. Digital electronics and calculation of digital circuits 3. Converters (Analog – Digital, Digital – Analog) 4. Principle of digital memory and communication, 5. Microprocessors and Networks 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic terms, concepts and phenomena of electronic and electrical engineering for the use in the Lab, • have skills in easy circuit design, measuring and control technology and digital electronics, • have expertise in independent working on circuit problems. They develop easy digital circuits and program microprocessors 		
Workload: Total: 180 h 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 60 h lecture and exercise course (attendance)		
Conditions: none		
Frequency: each summer semester	Recommended Semester:	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Digital Electronics for Physicists and Materials Scientists Mode of Instruction: lecture + exercise Lecturers: Andreas Hörner Language: English Contact Hours: 4 ECTS Credits: 6.0		
Examination Digital Electronics Digital Electronics for Physicists and Materials Scientists written exam / length of examination: 90 minutes		

Module PHM-0228: Symmetry concepts and their applications in solid state physics and materials science <i>Symmetry concepts and their applications in solid state physics and materials science</i>	6 ECTS/LP
Version 1.0.0 (since WS18/19) Person responsible for module: Prof. Dr. István Kézsmárki Deisenhofer, Joachim, Dr.	
<p>Contents:</p> <p>The topical outline of the course is as follows:</p> <ul style="list-style-type: none"> • Introduction and common examples <ul style="list-style-type: none"> o Motivating examples o Polar and axial vectors and tensors o Spatial and temporal symmetries and charge conjugation o Symmetries of measurable quantities and fields o Symmetries of physical laws (classical and quantum) o Conservation laws (linear and angular momentum, energy, etc.) o Symmetry of measurement configurations (reciprocity, etc.) • Neumann principle <ul style="list-style-type: none"> o Linear response theory and Onsager relations o Applications to vector and tensor quantities: electric and magnetic dipole moment of molecules; ferroelectricity, ferromagnetism, piezoelectricity and magnetoelectricity in crystals; wave propagation in anisotropic media (sound and light) • Symmetry allowed energy terms <ul style="list-style-type: none"> o On the level of classical free energy: Polar, nematic and magnetic order parameters (Landau expansion) o On the level of Hamiltonians: Molecular vibrations, crystal field potential, magnetic interactions • Symmetry of physical states <ul style="list-style-type: none"> o Spatial inversion and parity eigenstates o Discrete translations and the Bloch states • Spontaneous symmetry breaking upon phase transitions (Landau theory) • Outlook: Symmetry guides for skyrmion-host materials, multiferroic compounds and axion insulators 	
<p>Learning Outcomes / Competences:</p> <ul style="list-style-type: none"> • The students know the simple use of symmetry concepts to understand phenomena and material properties without performing detailed calculations. • The students know how to make minimal plans for experiments using the symmetry of the studied materials or vice versa how to determine the symmetry of materials from the output of experiments. • The students acquire scientific skills to search for scientific literature and to evaluate scientific content. 	
<p>Workload:</p> Total: 180 h 60 h (attendance) 60 h exam preparation (self-study) 60 h studying of course content (self-study)	

Conditions: Background in basic quantum mechanics is required.		
Frequency: nach Bedarf WS und SoSe	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
<p>Part of the Module: Symmetry concepts and their applications in solid state physics and materials science</p> <p>Mode of Instruction: lecture</p> <p>Lecturers: Prof. Dr. István Kézsmárki</p> <p>Language: English</p> <p>Contact Hours: 3</p> <p>ECTS Credits: 6.0</p>
<p>Examination</p> <p>Symmetry concepts and their applications in solid state physics and materials science</p> <p>oral exam / length of examination: 30 minutes</p>

Parts of the Module
<p>Part of the Module: Symmetry concepts and their applications in solid state physics and materials science (Tutorial)</p> <p>Mode of Instruction: exercise course</p> <p>Language: English</p> <p>Contact Hours: 1</p>

Module PHM-0252: Optical Excitations in Materials <i>Optical Excitations in Materials</i>		6 ECTS/LP
Version 1.9.0 (since SoSe20) Person responsible for module: Prof. Dr. Joachim Deisenhofer		
Contents:		
1. Classical Light-Matter Interaction in Solids:		
<ul style="list-style-type: none"> • Introduction: Typical Optical Response of Metals and Semiconductors • Classical electromagnetic wave propagation in linear optical media (Maxwell Equations, refractive index, reflection, transmission, absorption) • Anisotropic media, birefringence, longitudinal solutions • Classical Drude-Lorentz oscillator model • Spectroscopic techniques: Fourier-Transform-Spectroscopy, Time-domain Spectroscopy, Ellipsometry 		
2. Quantum Aspects of Light-Matter interaction		
<ul style="list-style-type: none"> • qm approach to absorption and emission: Lorentzian lineshape, Fermi's Golden Rule • Electric-dipole and magnetic-dipole approximation • Rabi-oscillations and the need for quantum optical approaches • A glimpse of non-linear optics 		
3. Excitations in different material classes		
<ul style="list-style-type: none"> • Optical properties of semiconductors/insulators, molecular materials, metals • Absorption and Luminescence, excitons, luminescence centers • Optoelectronics, detectors, light emitting devices • Quantum confined structures: tuning of absorption and emission 		
Learning Outcomes / Competences:		
<ul style="list-style-type: none"> • The students gain basic knowledge of the fundamental concepts of light-matter interaction in solids. • The students have detailed knowledge of classical models of light-propagation and absorption and get the competence to choose adequate spectroscopic techniques for measuring the optical properties of different material classes. • The students have a basic understanding of quantum aspects of optical processes in different materials. • The students are able apply these concepts to understand and analyse optical properties of different materials. • The students acquire scientific skills to search for scientific literature and to evaluate scientific content. 		
Workload:		
Total: 180 h		
20 h studying of course content using literature (self-study)		
80 h studying of course content through exercises / case studies (self-study)		
20 h studying of course content using provided materials (self-study)		
60 h lecture and exercise course (attendance)		
Conditions:		
Basic knowledge of classical electrodynamics, atomic and solid state physics.		
Frequency: each semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module

Part of the Module: Optical Excitations in Materials

Mode of Instruction: lecture

Language: English

Contact Hours: 4

ECTS Credits: 6.0

Literature:

1. Mark Fox, Optical Properties of Solids, Oxford Master Series
2. Mark Fox, Quantum Optics: An Introduction, Oxford Master Series
3. David B. Tanner, Optical Effects in Solids, Cambridge University Press
4. Y. Toyozawa, Optical Processes in Solids, Cambridge University Press

Assigned Courses:

Optical Excitations in Materials (lecture)

Examination

Optical Excitations in Materials

written exam / length of examination: 90 minutes

Module PHM-0253: Dielectric Materials <i>Dielectric Materials</i>		6 ECTS/LP
Version 1.2.0 (since SoSe20) Person responsible for module: PD Dr. Peter Lunkenheimer		
Contents: <ul style="list-style-type: none"> • Experimental techniques: quantities, broadband dielectric spectroscopy, nonlinear and polarization measurements • Dynamic processes in dielectric materials: relaxation processes, phenomenological models • Dielectric properties of disordered matter: liquids, glasses, plastic crystals • Charge transport: hopping conductivity, universal dielectric response • Ionic conductivity: conductivity mechanism, dielectric properties, advanced electrolytes for energy-storage devices • Maxwell-Wagner relaxations: equivalent-circuits, applications (supercapacitors), colossal-dielectric-constant materials • Electroceramics: Materials, Properties (relaxor ferroelectric, ferroelectric, antiferroelectric and multiferroic), Applications 		
Learning Outcomes / Competences: Students know the fundamentals of electromagnetic wave propagation and have a sound background for a broad spectrum of dielectric phenomena. They are able to analyze materials requirements and to interpret dielectric spectra in a broad frequency range. They have the competence to select materials for different kinds of applications and to critically assess experimental results on dielectric properties.		
Remarks: Elective compulsory module		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: Basic knowledge of solid state physics		
Frequency: each summer semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Dielectric Materials Mode of Instruction: lecture Lecturers: PD Dr. Stephan Krohns, PD Dr. Peter Lunkenheimer Language: English / German		

Literature:

- F. Kremer and A. Schönhal (eds.), Broadband Dielectric Spectroscopy (Springer, Berlin, 2002).
- F. Kremer and A. Loidl (eds.), The scaling of relaxation processes (Springer, Cham, 2018).
- A.K. Jonscher, Dielectric Relaxations in Solids (Chelsea Dielectrics Press, London, 1983).
- C.J.F. Böttcher and P. Bordewijk, Theory of electric polarisation Vol II (Elsevier, Amsterdam, 1973).
- S.R. Elliott, Physics of Amorphous Materials (Longman, London, 1990)
- A.J.Moulson, J.M. Herbert, Electroceramics: Materials, Properties, Applications (Wiley, 2003)
- R. Waser, U. Böttger, S. Tiedke, Polar Oxides: Properties, Characterization, and Imaging (Wiley, 2005)

Examination

Dielectric Materials Dielectric Materials

presentation / length of examination: 45 minutes

Examination Prerequisites:

Dielectric Materials

Module PHM-0266: Analytical Methods for Crystalline Sustainable Materials <i>Analytical Methods for Crystalline Sustainable Materials</i>		6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Christine Kuntscher		
Contents: The course will introduce diffraction methods and various spectroscopic methods including x-ray diffraction, energy-dispersive x-ray spectroscopy, photoemission spectroscopy, infrared and Raman spectroscopy, scanning electron microscopy, and scanning tunneling microscopy and spectroscopy.		
Learning Outcomes / Competences: After attending the course, the students will know the physical basics of various analytical methods and their possible applications for the characterization of crystalline sustainable materials.		
Workload: Total: 180 h 120 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Recommended: good knowledge in materials science		Credit Requirements: Bestehen der Modulprüfung
Frequency:	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Analytical Methods for Crystalline Sustainable Materials Mode of Instruction: lecture Language: English / German Contact Hours: 4		
Literature: J. M. Hollas, Modern Spectroscopy, Wiley-VCH (2003) H. Kuzmany, Solid State Spectroscopy, Springer (2009) S. Hüfner, Photoelectron Spectroscopy, Springer (1995)		
Part of the Module: Übung zu Analytical Methods for Crystalline Sustainable Materials Mode of Instruction: exercise course Language: English / German Contact Hours: 1		
Examination Analytical Methods for Crystalline Sustainable Materials written exam / length of examination: 90 minutes		

Module PHM-0267: Fundamentals of Materials for Energy <i>Fundamentals of Materials for Energy</i>		6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Wolfgang Brütting		
Contents: This class teaches fundamentals of conventional as well as renewable energy conversion. The following topics will be addressed: <ul style="list-style-type: none"> • Basics facts on energy conversion and climate change • Fossil energy • Nuclear energy • Renewable energy • Energy storage and transport 		
Learning Outcomes / Competences: Students know the fundamentals of different energy technologies. They are able to assess their respective efficiency and their potential for covering current and future energy demand. They are able to deal with a specific problem using up-to-date literature and participate in the ongoing discussion about how to cover our increasing need for various forms of energy.		
Conditions: Sound background in physics, in particular solid state physics and thermodynamics.		Credit Requirements: Passing the exam
Frequency: annually	Recommended Semester:	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Fundamentals of Materials for Energy Mode of Instruction: lecture Language: English / German Contact Hours: 4 ECTS Credits: 6.0		
Literature: <ul style="list-style-type: none"> • D.S. Ginley, D. Cahen: Fundamentals of Materials for Energy and Environmental Sustainability (Cambridge Univ. Press) • J. Fricke, W.L. Borst: Essentials of Energy Technology (Wiley-VCH) • D.J.C. MacKay: Sustainable Energy - without the hot air (https://www.withouthotair.com/) 		
Assigned Courses: Fundamentals of Materials for Energy (lecture)		
Examination Fundamentals of Materials for Energy written exam / length of examination: 90 minutes		

Module PHM-0268: Porous Functional Materials <i>Poröse funktionale Materialien</i>	6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Dirk Volkmer	
Contents: (i) Einleitung und historischer Überblick (ii) Theorie (1) Wichtige Klassen poröser Materialien: Strukturen und Herstellungsmethoden a) Zeolithe, MCM-Materialien und silikatische Aergel b) Poröse Kohlenstoffe u. Kohlenstoffnitride c) Metall-Organische Gerüstverbindungen (MOFs) d) Kovalente Organische Gerüstverbindungen e) Poröse Flüssigkeiten und Gläser f) Flexible und Stimulus-responsive poröse Materialien (2) Physisorption in porösen Materialien a) Instrumentelle Methoden zur Bestimmung von spezifischer Oberfläche und Porosität b) Auswertung von Physisorptionsisothermen c) Atomistische Modellierung von Diffusion und Stofftransport (3) Ausgewählte Methoden der Struktur- und Thermoanalytik zur Charakterisierung poröser Materialien a) Thermoanalytische Methoden b) Dynamische Chemisorptionsanalyse c) Multikomponenten-Gasadsorption, Durchbruchkurven und IAST (iii) Anwendungen (4) Speicherung chemischer Stoffe in porösen Materialien a) Speicherung von wichtigen Energieträgern (H ₂ /Methan) b) CO ₂ -Fixierung c) Pharmakologischer Wirkstofftransport u.-freisetzung (5) Stofftrennprozesse a) Poröse Materialien in industriellen Trennprozessen b) Membran-Trenntechnologie (6) Heterogene Katalyse a) Zeolithe in der industriellen Katalyse b) Photokatalyse u. künstl. Photosynthese (7) Integration poröser Materialien in integrierte Schaltkreise und Sensoren	
Learning Outcomes / Competences: <ul style="list-style-type: none"> • Die Studierenden wissen die Designprinzipien, Herstellungs- und Charakterisierungsmethoden poröser Materialien, • wissen wichtige technische Anwendungen poröser Materialien • besitzen die Fertigkeit zur atomistischen Modellierung von porösen Materialien und Sorptionsprozessen • besitzen die Fertigkeit zur mathematischen Auswertung von Sorptions-analytischen Daten zur Bestimmung der spezifischen Oberfläche und Porosität der Materialien • besitzen Kompetenzen in der selbstständigen Bearbeitung von Problemstellungen aus den genannten Themenbereichen 	
Remarks: Das Modul kann in den Studiengängen Master Materialchemie und Master Materials Science and Engineering belegt werden	
Workload: Total: 180 h 30 h studying of course content using provided materials (self-study)	

30 h studying of course content using literature (self-study) 60 h studying of course content through exercises / case studies (self-study) 45 h lecture (attendance) 15 h exercise course (attendance)		
Conditions: keine		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 3.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module**Part of the Module: Poröse funktionale Materialien****Mode of Instruction:** lecture**Language:** German**Contact Hours:** 3**Lehr-/Lernmethoden:**

Beamerpräsentation, Blended Learning

Part of the Module: Übung zu Poröse funktionale Materialien**Mode of Instruction:** exercise course**Language:** German**Contact Hours:** 1**Lehr-/Lernmethoden:**

Tutorium, Beamerpräsentationen, Tafelanschrieb

Literature:

- Pascal Van Der Voort, Karen Leus, Els De Canck, Introduction to Porous Materials (Wiley, 1. Ausgabe 2019), ISBN-13 # : # 978-1119426608

Examination**Poröse funktionale Materialien**

oral exam, Einzel oder Gruppenprüfung (Prüfungsdauer pro Person) / length of examination: 30 minutes

Module PHM-0269: Materials for electrochemical energy storage <i>Materialien zur elektrochemischen Energiespeicherung</i>		6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Leo van Wüllen		
Contents: <ul style="list-style-type: none"> • elektrochemische Grundlagen • elektrochemische Energiespeicher: Superkondensatoren und Batterien • Batteriesysteme • Li-Ionen-Batterien • Redox-flow-Batterien • Metall-Fluorid-Batterien • Neue Materialien für Anode, Kathode, Elektrolyt und Separator 		
Learning Outcomes / Competences: Die Studierenden <ul style="list-style-type: none"> • kennen die grundlegenden Konzepte zur elektrochemischen Energiespeicherung • erhalten spezifische Kenntnisse über die wichtigsten aktuellen Batterie- und Akkumulatorsysteme • erhalten die Fertigkeit, für spezifische Einsatzfelder die geeigneten Batteriesysteme zu identifizieren • erwerben die Kompetenz, Materialien hinsichtlich ihrer Eignung als Anoden-, Kathoden- und Elektrolytmaterialien auszuwählen und zu beurteilen • Integrierter Erwerb von Schlüsselqualifikationen: Fähigkeit sich in ein naturwissenschaftliches Spezialgebiet einzuarbeiten und das erworbene Wissen aktiv zur Lösung wissenschaftlicher Fragestellungen anzuwenden 		
Remarks: Das Modul kann auch im Studiengang Master Materials Science and Engineering belegt werden.		
Workload: Total: 180 h 15 h exercise course (attendance) 45 h lecture (attendance) 120 h studying of course content using provided materials (self-study)		
Conditions: none		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Materialien zur elektrochemischen Energiespeicherung Mode of Instruction: lecture Language: German Contact Hours: 3		
Learning Outcome: siehe Modulbeschreibung		
Contents: siehe Modulbeschreibung		

Literature:

Hamann, C. H., Vielstich, W. (2005). *Elektrochemie*. (4. Auflage) Wiley-VCH Verlag GmbH.
Job, R. (2020). *Electrochemical Energy Storage*. Walter de Gruyter GmbH.
Kurzweil, P. (2015). *Elektrochemische Speicher: Superkondensatoren, Batterien, Elektrolyse-Wasserstoff, Rechtliche Rahmenbedingungen*. Springer-Verlag Berlin Heidelberg.

Part of the Module: Übung zu Materialien zur elektrochemischen Energiespeicherung

Mode of Instruction: exercise course

Language: German

Contact Hours: 1

Learning Outcome:

siehe Modulbeschreibung

Examination

Materialien zur elektrochemischen Energiespeicherung

oral exam, Einzel- oder Gruppenprüfung; Prüfungsdauer pro Person: 30 Minuten

Module PHM-0271: Photonic Materials <i>Photonische Materialien</i>		6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Henning Höppe		
Contents: <ul style="list-style-type: none"> • Einführung in grundlegende Konzepte • Silicatanaloge Materialien und Halbleiter • Lumineszierende Materialien • Pigmente • Anwendungsbeispiele • Grundsätze guter wissenschaftlicher Praxis 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • Die Studierenden kennen die grundlegenden theoretischen Konzepte (wie Ligandenfeld- und Bändertheorie), die zur Beschreibung charakteristischer Bindungsverhältnisse in Festkörpern notwendig sind; sie sind vertraut mit den Ordnungsprinzipien in Festkörpern (Kristallographie und Gruppentheorie) und verfügen über Grundkenntnisse in Stoffchemie und Festkörpersynthesen • Die Studierenden können die optischen Eigenschaften photonischer Materialien erklären und analysieren. • Sie erwerben die Kompetenz, ausgehend von bekannten Materialien die Eigenschaften neuer Verbindungen abzuschätzen und einen sinnvollen synthetisch-strategischen Zugang zu diesen Verbindungen zu erarbeiten. • Integrierter Erwerb von Schlüsselqualifikationen: Fähigkeit sich in ein naturwissenschaftliches Spezialgebiet einzuarbeiten und das erworbene Wissen aktiv zur Lösung wissenschaftlicher Fragestellungen anzuwenden 		
Remarks: Das Modul kann in den Studiengängen Master Materialchemie und Master Materials Science and Engineering belegt werden.		
Workload: Total: 180 h 15 h exercise course (attendance) 45 h lecture (attendance) 20 h studying of course content using provided materials (self-study) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study)		
Conditions: none		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Photonische Materialien Mode of Instruction: lecture Language: German Contact Hours: 3		
Learning Outcome: siehe Modulbeschreibung		

Contents:

siehe Modulbeschreibung

Literature:

- W. Yen, S. Shionoya, H. Yamamoto, Phosphor Handbook, The CRC Press laser and optical science and technology series, CRC Press/Taylor and Francis, 2007.
- B. Henderson und G. Imbusch, Optical spectroscopy of inorganic solids, Monographs on the Physics and Chemistry of Materials, Oxford University Press, 2006.
- A. Fox, Optical Properties of Solids, Oxford master series in condensed matter physics, Oxford University Press, 2001.
- weitere wird in der Vorlesung bekanntgegeben

Assigned Courses:

Photonische Materialien (lecture + exercise)

Part of the Module: Übung zu Photonische Materialien

Mode of Instruction: exercise course

Language: German

Contact Hours: 1

Learning Outcome:

siehe Modulbeschreibung

Examination

Photonische Materialien

written exam / length of examination: 90 minutes

Module PHM-0274: Materials under extreme conditions <i>Materialien unter extremen Bedingungen</i>		6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Wolfgang Scherer		
Contents: <ul style="list-style-type: none"> • Einführung in die Hochtemperatur- und Hochdruckchemie in Lösung und im Festkörper • Experimentelle Techniken zur Synthese und Charakterisierungen von Materialien unter extremen Bedingungen • Einfluss von Druck und Temperatur auf die Reaktionen anorganischer und organischer Verbindungen • Materialeigenschaften und physikalischen Eigenschaften von Festkörpern unter extremen Bedingungen • Anwendungen in der Hochdruckchemie und Design von Materialien 		
Learning Outcomes / Competences: Die Studierenden <ul style="list-style-type: none"> • erlangen Grundkenntnisse in der Synthese und <i>in-situ</i> Charakterisierung von Festkörpern und molekularen Materialien bei hohem Druck und hohen Temperaturen. • kennen die grundlegenden Konzepte, die zum Verständnis der komplexen Bindungsverhältnisse, Strukturchemie und physikalischer Eigenschaften von Materialien unter extremen Bedingungen unabdingbar sind: <ul style="list-style-type: none"> - Molekülorbitaltheorie - Bandstrukturanalyse - Ligandenfeldtheorie - spektroskopische Methoden - Beugungsmethoden • erlangen die Fähigkeit strukturelle und physikalische Phasenübergänge in Abhängigkeit von Druck und Temperatur zu analysieren und interpretieren. • können grundlegende Strategien anwenden, um die elektronische Struktur von Festkörpern und damit die Materialeigenschaften in Abhängigkeit externer Kontrollparameter (Druck, Temperatur) maßzuschneidern. Damit erwerben sie die Schlüsselqualifikation, sich in ein naturwissenschaftliches Spezialgebiet einzuarbeiten und das erworbene Wissen zur Lösung anwendungsorientierter Fragestellungen, wie dem Design von Materialien mit maßgeschneiderten physikalischen Eigenschaften, umzusetzen. 		
Remarks: Das Modul kann in den Studiengängen Master "Materialchemie" und Master "Materials Science and Engineering" belegt werden.		
Workload: Total: 180 h 45 h lecture (attendance) 15 h exercise course (attendance) 30 h studying of course content using literature (self-study) 60 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using provided materials (self-study)		
Conditions: none		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 3.	Minimal Duration of the Module: 1 semester[s]

Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
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Parts of the Module**Part of the Module: Materialien unter extremen Bedingungen****Mode of Instruction:** lecture**Language:** German**Contact Hours:** 3**Learning Outcome:**

siehe Modulbeschreibung

Contents:

siehe Modulbeschreibung

Lehr-/Lernmethoden:

Vorlesung, Beamerpräsentation, Tafelanschrieb

Literature:

- R. van Eldik, F.-G. Klärner, *High Pressure Chemistry: Synthetic, Mechanistic, and Supercritical Applications*, WILEY-VCH, 1st Ed., 2002
- V.D. Blank, E.I. Estrin, *Phase Transitions in Solids Under High Pressure*, CRC Press, 1st Ed., 2014.
- J. Gilman, *Electronic Basis of the Strength of Materials*, Cambridge, 1st Ed., 2014.
- R. M. Hazen, R.T. Downs, *High-Temperature and High-Pressure Crystal Chemistry*, Mineralogical Society of America, 2000.
- U. Schubert, N. Hüsing, *Synthesis of Inorganic Materials*, Wiley-VCH, 3rd Edition, 2012.
- N. Wiberg, *Lehrbuch der Anorganischen Chemie*, Walter de Gruyter, ebook, 102. Auflage, 2007.

Part of the Module: Übungen zu Materialien unter extremen Bedingungen**Mode of Instruction:** exercise course**Language:** German**Contact Hours:** 1**Learning Outcome:**

siehe Modulbeschreibung

Examination**Materialien unter extremen Bedingungen**

written exam / length of examination: 90 minutes

Module PHM-0146: Method Course: Electronics for Physicists and Materials Scientists <i>Method Course: Electronics for Physicists and Materials Scientists</i>		8 ECTS/LP
Version 2.0.0 (since SoSe22) Person responsible for module: Andreas Hörner		
Contents: <ol style="list-style-type: none"> 1. Basics in electronic and electrical engineering 2. Quadrupole theory 3. Analog technique, transistor and opamp circuits 4. Boolean algebra and logic 5. Digital electronics and calculation circuits 6. Microprocessors and Networks 7. Basics in Electronic 8. Implementation of transistors 9. Operational amplifiers 10. Digital electronics 11. Practical circuit arrangement 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic terms, concepts and phenomena of electronic and electrical engineering for the use in the laboratory, • have skills in easy circuit design, measuring and control technology, analog and digital electronics, • have expertise in independent working on circuit problems. They can calculate and develop easy circuits. 		
Remarks: ELECTIVE COMPULSORY MODULE Attendance in the Method Course: Electronics for Physicists and Materials Scientists (combined lab course AND lecture) excludes credit points for the lecture Electronics for Physicists and Materials Scientists .		
Workload: Total: 240 h 140 h studying of course content using provided materials (self-study) 60 h lecture (attendance) 10 h preparation of written term papers (self-study) 30 h internship / practical course (attendance)		
Conditions: none		Credit Requirements: written report (one per group)
Frequency: each semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Method Course: Electronics for Physicists and Materials Scientists Mode of Instruction: lecture Language: English Contact Hours: 4		

Literature:

- Paul Horowitz: The Art of Electronics (Cambridge University Press)
- National Instruments: MultiSim software package (available in lecture)

Assigned Courses:

Method Course: Electronics for Physicists and Materials Scientists (lecture)

Part of the Module: Method Course: Electronics for Physicists and Materials Scientists (Practical Course)

Mode of Instruction: laboratory course

Language: English

Contact Hours: 2

Assigned Courses:

Method Course: Electronics for Physicists and Materials Scientists (Practical Course) (internship)

Examination

Method Course: Electronics for Physicists and Materials Scientists

written exam / length of examination: 90 minutes

Module PHM-0147: Method Course: Electron Microscopy <i>Method Course: Electron Microscopy</i>		8 ECTS/LP
Version 1.3.0 (since SoSe15) Person responsible for module: Prof. Dr. Ferdinand Haider		
Contents: Scanning electron microscopy (SEM) <ul style="list-style-type: none"> • Electron optical components • Detectors • EDX, EBSD Transmission electron microscopy (TEM) <ul style="list-style-type: none"> • Diffraction • Contrast mechanisms • High resolution EM • Scanning TEM • Analytical TEM • Aberration correction 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • get introduced to the basics of scanning electron microscopy and transmission electron microscopy, using lectures to teach the theoretical basics, which are afterwards deepened using practical courses, • are able to operate SEM and TEM on a basic level • are able to characterize materials using different electron microscopy techniques • Acquire the competence to decide about a technique feasible for a certain problem. • acquire the competence to assess EM images, also regarding artefacts • learn to search for scientific literature and to formulate a scientific report 		
Remarks: ELECTIVE COMPULSORY MODULE		
Workload: Total: 240 h 90 h lecture and exercise course (attendance) 150 h studying of course content using provided materials (self-study)		
Conditions: Recommended: knowledge of solid-state physics, reciprocal lattice		Credit Requirements: regular participation, oral presentation (10 min), written report (one report per group)
Frequency: each summer semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Method Course: Electron Microscopy Mode of Instruction: lecture Language: English Contact Hours: 2		

Contents:

SEM:

1. Layout of Electron Microscopes and Electron Optical Components
2. Electron Solid Interactions
3. Contrast Formation in Scanning Electron Microscopy (SEM)
4. SE/BSE contrast
5. Electron Back Scattering Diffraction (EBSD)
6. Analytical techniques
7. Special Applications of SEM

TEM:

1. TEM specimen preparation techniques
2. Components of a TEM, principle lens design, lens aberrations
3. Electron diffraction: fundamentals
4. Contrast formation at bright field, dark field, weak beam dark field, and many beam conditions, „chemical“ imaging
5. Bright field, dark field, weak beam dark field imaging of dislocations
6. Kinematical theory of electron wave propagation in crystals
7. Howie Whelan equations, contrast of defects
8. High resolution TEM, lattice imaging of crystals
9. Advanced diffraction techniques: Kikuchi patterns, HOLZ lines and Convergent Beam Diffraction (CBED)
10. Image simulation
11. Analytical TEM: Electron energy loss spectroscopy & energy filtered TEM

Literature:

- D.B.Williams and C.B.Carter, Transmission Electron Microscopy, Plenum Press, New York/London, 1996
- M.A. Hirsch, A. Howie, R. Nicholson, D.W. Pashley, M.J. Whelan, Electron microscopy of thin crystals, Krieger Publishing Company, Malabar (Florida), 1977
- L. Reimer, Transmission electron microscopy, Springer Verlag, Berlin/Heidelberg/New York, 1984
- P.J. Goodhew, Thin foil preparation for electron microscopy, Elsevier, Amsterdam, 1985
- P.R. Buseck, J.M. Cowley, L. Eyring, High-resolution transmission electron microscopy, Oxford University Press, 1988
- E. Hornbogen, B. Skrotzki, Werkstoff-Mikroskopie, Springer Verlag, Berlin/Heidelberg/New York, 1995
- K. Wetzig, In situ scanning electron microscopy in materials research, Akad.-Verl., 1995
- J. I. Goldstein, Scanning electron microscopy and x-ray microanalysis, Plenum Press, 1992
- L. Reimer, Scanning electron microscopy, Springer Verlag, 1985
- S. L. Flegler, J. W. Heckman, K. L. Klomparens, Elektronenmikroskopie, Spektrum, Akad. Verl., 1995

Part of the Module: Method Course: Electron Microscopy (Practical Course)

Mode of Instruction: laboratory course

Language: English

Contact Hours: 4

Examination

Method Course: Electron Microscopy

report

Examination Prerequisites:

Method Course: Electron Microscopy

Module PHM-0148: Method Course: Optical Properties of Solids <i>Method Course: Optical Properties of Solids</i>		8 ECTS/LP
Version 1.4.0 (since SoSe15) Person responsible for module: Prof. Dr. Joachim Deisenhofer		
Contents: Electrodynamics of solids <ul style="list-style-type: none"> • Maxwell equations • Electromagnetic waves • Refraction and interference, Fresnel equations FTIR spectroscopy <ul style="list-style-type: none"> • Fourier transformation • Michelson-Morley and Genzel interferometer • Sources and detectors Terahertz Time Domain spectroscopy <ul style="list-style-type: none"> • Generation of pulsed THz radiation • Gated detection, Austin switches Elementary excitations in solid materials <ul style="list-style-type: none"> • Rotational-vibrational bands • Infrared-active phonons • Interband excitations • Crystal-field excitations 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students know the basic principles of far-infrared spectroscopy and terahertz time-domain-spectroscopy, • The students know about fundamental optical excitations in condensed matter materials that can be studied by these spectroscopic methods, • The students obtain the competence to plan and carry out complex experiments, • The students have the skills to evaluate and analyze optical data. • The students acquire scientific skills to search for scientific literature and to evaluate scientific content. 		
Remarks:		
Workload: Total: 240 h 30 h studying of course content using provided materials (self-study) 90 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using literature (self-study) 90 h lecture and exercise course (attendance)		
Conditions: Recommended: basic knowledge in solid-state physics, basic knowledge in electrodynamics and optics		Credit Requirements: written report
Frequency: each semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Method Course: Optical Properties of Solids Mode of Instruction: lecture Language: English Contact Hours: 2
Literature: Mark Fox, Optical Properties of Solids, Oxford Master Series Eugene Hecht, Optics, Walter de Gruyter
Part of the Module: Method Course: Optical Properties of Solids (Practical Course) Mode of Instruction: laboratory course Language: English Contact Hours: 4
Examination Method Course: Optical Properties of Solids report Examination Prerequisites: Method Course: Optical Properties of Solids

Module PHM-0149: Method Course: Methods in Biophysics <i>Method Course: Methods in Biophysics</i>		8 ECTS/LP
Version 2.0.0 (since SoSe22) Person responsible for module: Dr. Christoph Westerhausen		
Contents: Unit Membrane biophysics <ul style="list-style-type: none"> • Preparation of synthetic lipid membranes • Size, fluorescence and phase transition characterization of lipid membranes • Nanoparticle uptake synthetic membrane Unit microfluidic <ul style="list-style-type: none"> • Microfluidic systems • Fabrication of microfluidic systems • Calculation of microfluidic problems Unit live cell experiments <ul style="list-style-type: none"> • Cell culture • Cell coating and separation using microfluidics Unit analysis		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know basic terms, concepts and phenomena in biophysics • acquire basic knowledge of fluidic and biophysical phenomena on small length scales and applications and technologies of microfluidic manipulation and analysis systems, • learn skills in tissue culture and immun-histochemical staining procedures, • learn skills in fluorescence microscopy, • learn skills to calculate fluidic problems on small length scales, • learn skills to handle microfluidic channel systems. 		
Remarks: ELECTIVE COMPULSORY MODULE		
Workload: Total: 240 h		
Conditions: Attendance of the lecture "Biophysics and Biomaterials"		Credit Requirements: 1 written lab report
Frequency: each summer semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Method Course: Methods in Biophysics Mode of Instruction: lecture Language: English Contact Hours: 2		

Part of the Module: Method Course: Methods in Biophysics (Practical Course)

Mode of Instruction: laboratory course

Language: English

Contact Hours: 4

Literature:

- T. Herrmann, Klinische Strahlenbiologie – kurz und bündig, Elsevier Verlag, ISBN-13: 978-3-437-23960-1
- J. Freyschmidt, Handbuch diagnostische Radiologie – Strahlenphysik, Strahlenbiologie, Strahlenschutz, Springer Verlag, ISBN: 3-540-41419-3
- S. Haeberle und R. Zengerle, Microfluidic platforms for lab-on-a-chip applications, Lab-on-a-chip, 2007, 7, 1094-1110
- J. Berthier, Microdrops and digital microfluidics, William Andrew Verlag, ISBN:978-0-8155-1544-9
- Lecture notes

Examination

Method Course: Methods in Biophysics

report

Examination Prerequisites:

Method Course: Methods in Biophysics

Module PHM-0153: Method Course: Magnetic and Superconducting Materials <i>Method Course: Magnetic and Superconducting Materials</i>		8 ECTS/LP
Version 1.0.0 (since SoSe15) Person responsible for module: Prof. Dr. Philipp Gegenwart		
Contents: Methods of growth and characterization: Sample preparation (bulk materials and thin films), e.g., <ul style="list-style-type: none"> • arc melting • flux-growth • sputtering and evaporation Sample characterization, e.g., <ul style="list-style-type: none"> • X-ray diffraction • electron microscopy, scanning tunneling microscopy • magnetic susceptibility, electrical resistivity • specific heat 		
Learning Outcomes / Competences: The students <ul style="list-style-type: none"> • get to know the basic methods of materials growth and characterization, such as poly- and single crystal growth, thin-film growth, X-ray diffraction, magnetic susceptibility, dc-conductivity, and specific heat measurements • are trained in planning and performing complex experiments • learn to evaluate and analyze the collected data, are taught to work on problems in experimental solid state physics, including analysis of measurement results and their interpretation in the framework of models and theories 		
Workload: Total: 240 h 90 h lecture and exercise course (attendance) 30 h studying of course content using provided materials (self-study) 90 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using literature (self-study)		
Conditions: Recommended: basic knowledge in solid state physics and quantum mechanics		Credit Requirements: presentation and written report on the experiments (editing time 3 weeks, max. 30 pages)
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Method Course: Magnetic and Superconducting Materials Mode of Instruction: lecture Language: English Contact Hours: 2		
Assigned Courses:		

Method Course: Magnetic and Superconducting Materials (lecture)

Part of the Module: Method Course: Magnetic and Superconducting Materials (Practical Course)

Mode of Instruction: laboratory course

Language: English

Contact Hours: 4

Assigned Courses:

Method Course: Magnetic and Superconducting Materials (Practical Course) (internship)

Examination

Method Course: Magnetic and Superconducting Materials

report

Examination Prerequisites:

Method Course: Magnetic and Superconducting Materials

Module PHM-0154: Method Course: Modern Solid State NMR Spectroscopy <i>Method Course: Modern Solid State NMR Spectroscopy</i>		8 ECTS/LP
Version 2.0.0 (since SoSe17) Person responsible for module: Prof. Dr. Leo van Wüllen		
Contents: Physical foundations of NMR spectroscopy Internal interactions in NMR spectroscopy <ul style="list-style-type: none"> • Chemical shift interaction • Dipole interaction and • Quadrupolar interaction Magic Angle Spinning techniques Modern applications of NMR in materials science Experimental work at the Solid-State NMR spectrometers, computer-aided analysis and interpretation of acquired data		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • gain basic knowledge of the physical foundations of modern Solid-State NMR spectroscopy, • gain basic practical knowledge of operating a solid-state NMR spectrometer, • can -- under guidance -- plan, perform, and analyze modern solid-state NMR experiments for the structural characterization of advanced materials. 		
Remarks: ELECTIVE COMPULSORY MODULE		
Workload: Total: 240 h 30 h studying of course content using literature (self-study) 90 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using provided materials (self-study) 90 h lecture and exercise course (attendance)		
Conditions: The attendance of the lecture "NOVEL METHODS IN SOLID STATE NMR SPECTROSCOPY" is highly recommended.		Credit Requirements: Bestehen der Modulprüfung
Frequency: irregular	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Method Course: Modern Solid State NMR Spectroscopy Mode of Instruction: seminar Language: English Contact Hours: 2		

Literature:

- M. H. Levitt, spin Dynamics, John Wiley and Sons, Ltd., 2008.
- H. Günther NMR spectroscopy, Wiley, 2001.
- M. Duer, Introduction to Solid-State NMR spectroscopy, Blackwell Publishing Ltd., 2004.
- D. Canet, NMR - concepts and methods, Springer, 1994.

Part of the Module: Method Course: Modern Solid State NMR Spectroscopy (Practical Course)

Mode of Instruction: laboratory course

Language: English

Contact Hours: 4

Literature:

1. M. H. Levitt, Spin Dynamics, John Wiley and Sons, Ltd., 2008.
2. H. Günther, NMR spectroscopy, Wiley 2001.
3. M.Duer, Introduction to Solid-State NMR spectroscopy, Blackwell Publishing Ltd., 2004.
4. D. Canet: NMR - concepts and methods, Springer, 1994.

Examination

Method Course: Modern Solid State NMR Spectroscopy

report / work period for assignment: 2 weeks

Examination Prerequisites:

Method Course: Modern Solid State NMR Spectroscopy

Module PHM-0171: Method Course: Coordination Materials <i>Method Course: Coordination Materials</i>		8 ECTS/LP
Version 1.0.0 (since SoSe15) Person responsible for module: Prof. Dr. Dirk Volkmer Dr. Hana Bunzen		
Contents: 1. Synthesis of metal complexes: 2. Analytical characterization of metal complexes (thermal analysis, UV/vis spectroscopy, IR spectroscopy, X-ray diffraction) 3. Material composition and stability studies 4. Functional coordination materials (spin-crossover materials, oxygen-carrying materials)		
Learning Outcomes / Competences: The students will learn how to: <ul style="list-style-type: none"> • prepare transition metal complexes employing modern preparation techniques (e.g. microwave synthesis), inert synthesis conditions (Schlenk technique), • characterize coordination compounds by selected analytical techniques, • develop functional coordination materials based on organic / inorganic hybrid compounds, • employ X-ray diffraction methods for structural analysis. 		
Remarks: ELECTIVE COMPULSORY MODULE		
Workload: Total: 240 h 20 h studying of course content using provided materials (self-study) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 120 h lecture and exercise course (attendance)		
Conditions: none		Credit Requirements: written report (protocols)
Frequency: each summer semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Method Course: Coordination Materials (Practical Course) Mode of Instruction: laboratory course Language: English Contact Hours: 4		
Part of the Module: Method Course: Coordination Materials (Seminar) Mode of Instruction: seminar Language: English Contact Hours: 2		
Literature: <ul style="list-style-type: none"> • Chemical databases • Primary literature 		

Examination

Method Course: Coordination Materials (Seminar)

seminar

Examination Prerequisites:

Method Course: Coordination Materials (Seminar)

Module PHM-0206: Method Course: Infrared Microspectroscopy under Pressure <i>Method Course: Infrared Microspectroscopy under Pressure</i>		8 ECTS/LP
Version 1.0.0 (since WS16/17) Person responsible for module: Prof. Dr. Christine Kuntscher		
Contents: Electrodynamics of solids Maxwell equations and electromagnetic waves in matter Optical variables Theories for dielectric function: i. Free carriers in metals and semiconductors (Drude) ii. Interband absorptions in semiconductors and insulators iii. Vibrational absorptions iv. Multilayer systems FTIR microspectroscopy Components of FTIR spectrometers i. Light sources ii. Interferometers iii. Detectors Microscope components High pressure experiments Equipments Pressure calibration Experimental techniques under high pressure i. IR spectroscopy ii. Raman scattering iii. Magnetic measurements iv. Transport measurements		
Learning Outcomes / Competences: The students Learn about the basics of the light interaction with various materials and the fundamentals of FTIR microspectroscopy, Are introduced to the high pressure equipments used in infrared spectroscopy, Learn to carry out infrared microspectroscopy experiments under pressure, Learn to analyze the measured optical spectra.		
Workload: Total: 240 h		
Conditions: none		Credit Requirements: Written report
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
Part of the Module: Method Course: Infrared Microspectroscopy under Pressure Mode of Instruction: lecture Language: English Contact Hours: 2
Assigned Courses: Method Course: Infrared Microspectroscopy under Pressure (lecture)
Part of the Module: Method Course: Infrared Microspectroscopy under Pressure (Practical Course) Mode of Instruction: laboratory course Language: English Contact Hours: 4
Assigned Courses: Method Course: Infrared Microspectroscopy under Pressure (Practical Course) (internship)
Examination Method Course: Infrared Microspectroscopy under Pressure report

Module PHM-0216: Method Course: Thermal Analysis <i>Method Course: Thermal Analysis</i>		8 ECTS/LP
Version 1.0.0 (since WS16/17) Person responsible for module: Prof. Dr. Ferdinand Haider Dr. Robert Horny		
Contents: Methods of thermal analysis: - Differential Scanning Calorimetry: DSC, DTA - Thermo-gravimetric Analysis: TGA - Dilatometry: DIL - Dynamic-mechanical Analysis: DMA -Rheology: RHEO Advanced Methods: - Modulated Differential Scanning Calorimetry: MDSC - Evolved Gas Analysis: EGA (GCMS, FTIR)		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • get to know the basic principles of thermal analysis • learn about fundamental thermal processes in condensed matter ,e.g. phase transitions and relaxation processes (metals, polymers, ceramics) • learn to plan and carry out complex experiments and the usage of advanced measurement techniques • learn how to evaluate and analyze thermal data • are aware of common raw data artefacts leading to misinterpretation 		
Remarks:		
Workload: Total: 240 h 90 h lecture and exercise course (attendance) 90 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using literature (self-study) 30 h studying of course content using provided materials (self-study)		
Conditions: Recommended: basic knowledge in solid-state physics		Credit Requirements: regular participation, oral presentation (10 min), written report
Frequency: irregular	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Method Course: Thermal Analysis Mode of Instruction: lecture Lecturers: Prof. Dr. Ferdinand Haider Language: English Frequency: each winter semester Contact Hours: 2		

Literature:

- Differential scanning calorimetry, Höhne, Hemminger, Flammersheim, H., Springer, 2003
- Practical Gas Chromatography, Dettmer-Wilde, Engewald, Springer, 2014
- Das Rheologie-Handbuch, Mezger, Vincentz, 2010

Part of the Module: Method Course: Thermal Analysis (Practical Course)

Mode of Instruction: laboratory course

Language: English

Frequency: each winter semester

Contact Hours: 4

Examination

Method Course: Thermal Analysis

report

Module PHM-0221: Method Course: X-ray Diffraction Techniques <i>Method Course: X-ray Diffraction Techniques</i>		8 ECTS/LP
Version 1.3.0 (since WS15/16) Person responsible for module: Prof. Dr. Wolfgang Scherer PD Dr. Georg Eickerling		
<p>Contents:</p> <p>Subjects of the practical training and the accompanying lecture are the theoretical basics and the practical application of X-ray diffraction techniques:</p> <p>Data collection and reduction techniques</p> <p>Symmetry and space group determination</p> <p>Structural refinements:</p> <ul style="list-style-type: none"> • The Rietveld method • Difference Fourier synthesis <p>Structure determination:</p> <ul style="list-style-type: none"> • Patterson method • Direct methods <p>Interpretation of structural refinement results</p> <p>Errors and Pitfalls: twinning and disorder</p>		
<p>Learning Outcomes / Competences:</p> <p>The students:</p> <ul style="list-style-type: none"> • gain basic practical knowledge on structural characterization methods for single- and poly-crystalline samples employing X-ray diffraction techniques, • have the skill to perform under guidance phase-analyses and X-ray structure determinations • are competent to analyze hands-on the structure-property relationships of new materials 		
<p>Remarks:</p> <p>ELECTIVE COMPULSORY MODULE</p>		
<p>Workload:</p> <p>Total: 240 h</p> <p>30 h studying of course content using provided materials (self-study)</p> <p>30 h studying of course content using literature (self-study)</p> <p>90 h studying of course content through exercises / case studies (self-study)</p> <p>90 h lecture and exercise course (attendance)</p>		
Conditions: none		
Frequency: irregular	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module

Part of the Module: Method Course: X-ray Diffraction Techniques

Mode of Instruction: lecture

Language: English

Contact Hours: 2

Literature:

1. C. Giacovazzo et al., Fundamentals of Crystallography, Oxford Univ. Press, 2011.
2. W. Massa, Crystal structure determination, Berlin, Springer, 2016.

Part of the Module: Method Course: X-ray Diffraction Techniques (Practical Course)

Mode of Instruction: laboratory course

Language: German

Contact Hours: 4

Examination

Method Course: X-ray Diffraction Techniques

written exam / length of examination: 90 minutes

Module PHM-0223: Method Course: Tools for Scientific Computing <i>Method Course: Tools for Scientific Computing</i>	8 ECTS/LP
Version 1.5.0 (since SoSe18) Person responsible for module: Prof. Dr. Gert-Ludwig Ingold	
Contents: Important tools for scientific computing are taught in this module and applied to specific scientific problems by the students. As far as tools depend on a particular programming language, Python will be employed. Tools to be discussed include: <ul style="list-style-type: none"> • numerical libraries like NumPy and SciPy • visualisation of numerical results • use of a version control system like git and its application in collaborative work • testing of code • profiling • documentation of programs 	
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students are capable of solving a physical problem of some complexity by means of numerical techniques. They are able to visualize the results and to adequately document their program code. • The students know examples of numerical libraries and are able to apply them to solve scientific problems. • The students know methods for quality assurance like the use of unit tests and can apply them to their code. They know techniques to identify run-time problems. • The students know a distributed version control system and are able to use it in a practical problem. • The students have gained practical experience in a collaborative project work. They are able to plan and carry out a programming project in a small group. • The students understand the relevance of the tools taught in the method course for good scientific practice. 	
Remarks: The number of students will be limited to 12.	
Workload: Total: 240 h 60 h studying of course content (self-study) 90 h (attendance) 30 h preparation of presentations (self-study) 60 h preparation of written term papers (self-study)	
Conditions: Knowledge of the programming language Python is expected on the level taught in the module PHM-0243 "Einführung in Prinzipien der Programmierung".	Credit Requirements: The module examination needs to be passed which is based on a scientific programming project carried out in a small team of 2-3 students. The work will be judged on the basis of a joint final report and the contributions of the individual students as documented in the team's Gitlab project. The final report should contain an explanation of the scientific problem and its numerical implementation as well as a presentation of results. The code should be appropriately documented and tested.

Frequency: irregular	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module**Part of the Module: Method Course: Tools for Scientific Computing****Mode of Instruction:** lecture**Language:** English / German**Contact Hours:** 2**Learning Outcome:**

- The students know the numerical libraries NumPy and SciPy and selected tools for the visualization of numerical results.
- The students know fundamental techniques for the quality assurance of programs like the use of unit tests, profiling and the use of the version control system git. They are able to adequately document their code.
- The students understand the relevance of the tools taught in the method course for good scientific practice.

Contents:

- numerical libraries NumPy and SciPy
- graphics with matplotlib
- version control system Git and workflow for Gitlab/Github
- unit tests
- profiling
- documentation using docstrings and Sphinx

Literature:

- A. Scopatz, K. D. Huff, *Effective Computation in Physics* (O'Reilly, 2015)
- lecture notes are freely available at <https://gertingold.github.io/tools4scicomp>

Part of the Module: Method Course: Tools for Scientific Computing (Practical Course)**Mode of Instruction:** internship**Language:** English / German**Contact Hours:** 4**Learning Outcome:**

- The students are capable of solving a physical problem of some complexity by means of numerical techniques and to visualize the results.
- They have gained some experience in the application of methods for quality assurance of their code and are able to appropriately document their programs.
- The students are able to work in a team and know how to make use of tools like Gitlab/Github.
- The students are able to present the status of their work, to critically assess it and to accept suggestions from others.

Contents:

The tools discussed in the lecture will be applied to specific scientific problems by small teams of 2-3 students under supervision. The teams regularly inform the other teams in oral presentations on their progress, the tools employed as well as encountered problems and their solution.

Examination

Method Course: Tools for Scientific Computing

report / work period for assignment: 4 weeks

Description:

The requirement for credit points is based on a scientific programming project carried out in a small team of 2-3 students. The work will be judged on the basis of a joint final report and the contributions of the individual students as documented in the team's Gitlab project. The final report should contain an explanation of the scientific problem and its numerical implementation as well as a presentation of results. The code should be appropriately documented and tested.

Module PHM-0224: Method Course: Theoretical Concepts and Simulation <i>Method Course: Theoretical Concepts and Simulation</i>		8 ECTS/LP
Version 1.0.0 (since WS15/16) Person responsible for module: Prof. Dr. Liviu Chioncel		
Contents: This module covers Monte-Carlo methods (computational algorithms) for classical and quantum problems. Python as programming language will be employed. The following common applications will be discussed: <ul style="list-style-type: none"> • Monte-Carlo integration, stochastic optimization, inverse problems • Feynman path integrals: the connection between classical and quantum systems • Order and disorder in spin systems, fermions, and boson 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students are capable of obtaining numerical solutions to problems too complicated to be solved analytically • The students are able to present (graphically), discuss and analyze the results • The students gain experience in formulating and carrying out a collaborative project 		
Remarks: The number of students will be limited to 8.		
Workload: Total: 240 h 90 h preparation of presentations (self-study) 60 h preparation of written term papers (self-study) 60 h studying of course content (self-study) 90 h (attendance)		
Conditions: Knowledge of the programming language Python is expected on the level taught in the modul PHM-0041. Requirements to understand basic concepts in physics: Classical Mechanics (Newton, Lagrange), Electrodynamics, Thermodynamics and Quantum Mechanics.		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Method Course: Theoretical Concepts and Simulation Mode of Instruction: lecture Language: English / German Contact Hours: 2		
Contents: Concepts of classical and quantum statistical physics: <ul style="list-style-type: none"> • the meaning of sampling, random variables, ergodicity • equidistribution, pressure, temperature • path integrals, quantum statistics, enumeration, cluster algorithms 		
Literature: <ol style="list-style-type: none"> 1. Werner Krauth, Algorithms and Computations (Oxford University Press, 2006) 2. R. H. Landau, A Survey of Computational Physics (Princeton Univ. Press, 2010) 		

Part of the Module: Method Course: Theoretical Concepts and Simulation (Practical Course)

Mode of Instruction: internship

Language: English / German

Contact Hours: 4

Contents:

see above

Literature:

see above

Examination

Method Course: Theoretical Concepts and Simulation

report / work period for assignment: 4 weeks

Description:

The requirement for the credit points is based on a programming project carried out in a team of 2-3 students. The final report contains the formulation and a theoretical introduction into the problem, the numerical implementation, and the presentation of the results.

Module PHM-0258: Method course: Charge doping effects in semiconductors <i>Method course: Charge doping effects in semiconductors</i>		8 ECTS/LP
Version 1.0.0 (since SoSe21) Person responsible for module: Prof. Dr. István Kézsmárki Dr. Lilian Prodan, Dr. Somnath Ghara		
Contents: The goal of the method course is to make students familiar with the concept of controlling the type and the concentration of charge carriers in semiconductors, which is widely used approach in electronics and various fields of materials science. For this purpose, the current method course will be dealing with the preparation of various electron-doped and / or hole-doped narrow-gap semiconductors and investigation of the influence of charge doping on transport and magnetic properties. The following techniques will be involved: <ul style="list-style-type: none"> • Synthesis of electron and hole doped narrow-gap semiconductors, such as Zn- and Ge-doped GaV4S8, in polycrystalline forms using solid state reaction; • Refining the structure and checking phase purity by X-ray powder diffraction; • Resistivity and magneto-transport measurements; • Hall effect measurements to quantify carrier concentration; • Investigation of the doping-induced changes in the magnetic properties by magnetization measurements. 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students gain basic knowledge how to tailor the bulk properties of narrow-gap semiconductors via different doping techniques. • The students have detailed knowledge in performing XRD and magnetization experiments and know how to analyze the data. • The students acquire the competence to plan and perform Hall effect and magnetoresistance experiments and evaluate the obtained experimental results. • The students have the skill to distinguish between an n-type and p-type semiconductor. • The students know how to calculate the charge, mobility, and charge carrier density of a semiconductor using information obtained from the Hall effect experiments. 		
Remarks: ELECTIVE COMPULSORY MODULES		
Workload: Total: 240 h		
Conditions: Recommended: basic knowledge in solid state physics and semiconductors;		Credit Requirements: Written report on the experiments (editing time 2 weeks)
Frequency: each semester	Recommended Semester:	Minimal Duration of the Module: semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Method course: Charge doping effects in semiconductors (Practical Course) Mode of Instruction: internship Language: English Contact Hours: 4		

Contents:

The following techniques will be involved:

- Synthesis of electron and hole doped narrow-gap semiconductors, such as Zn- and Ge-doped GaV4S8, in poly-crystalline forms using solid state reaction;
- Refining the structure and checking phase purity by X-ray powder diffraction;
- Resistivity and magneto-transport measurements;
- Hall effect measurements to quantify carrier concentration;
- Investigation of the doping-induced changes in the magnetic properties by magnetization measurements.

Part of the Module: Method course: Charge doping effects in semiconductors

Mode of Instruction: lecture

Language: English

Contact Hours: 2

Learning Outcome:

The goal of the method course is to make students familiar with the concept of controlling the type and the concentration of charge carriers in semiconductors, which is widely used approach in electronics and various fields of materials science. For this purpose, the current method course will be dealing with the preparation of various electron-doped and / or hole-doped narrow-gap semiconductors and investigation of the influence of charge doping on transport and magnetic properties.

Examination

Method course: Charge doping effects in semiconductors

report

Module PHM-0285: Method Course: Computational Biophysics <i>Method Course: Computational Biophysics</i>		8 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Nadine Schwierz-Neumann		
Contents: Life relies on the interactions of proteins, nucleic acids, lipids and other biomolecules. This course introduces computational methods to study the structure, dynamics and mechanics of these biomolecules. In the first part of the course, the physics behind biomolecular simulations is explained and the basic principles of classical and statistical mechanics are reviewed. In the second part, different simulation techniques are introduced including molecular dynamics simulations and Monte Carlo simulations. Subsequently the methods are applied to biological systems consisting of proteins, nucleic acids and lipids		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • Students develop an active understanding of the principles, the capacity and limitations of biomolecular simulations • Students learn to solve typical biophysical problems analytically and numerically • Students learn how to run and analyze computer simulations of biological matter • Students learn to visualize, document and present their simulation results 		
Remarks: Number of students will be limited to 15.		
Workload: Total: 240 h 90 h exam preparation (self-study) 60 h studying of course content (self-study) 90 h (attendance)		
Conditions: Knowledge of classical mechanics on the bachelor level is expected.		Credit Requirements: Passing of the module exam
Frequency: irregular	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Method Course: Computational Biophysics Mode of Instruction: lecture Language: English / German Contact Hours: 2		
Learning Outcome: <ul style="list-style-type: none"> • Theoretical background of biomolecular simulations • Computational methods to describe the structure, dynamics and mechanics of biomolecules 		

Contents:

- Introduction to classical mechanics in phase space
- Probability and information theory
- Connection to statistical mechanics
- Molecular dynamics basics
- Monte Carlo Simulations
- Forces and force fields in biomolecular systems
- Simulations in different ensembles
- Calculating macroscopic thermodynamic properties from simulations

Literature:

- Daniel M. Zuckerman, *Statistical Physics of Biomolecules* (2010 by Taylor and Francis Inc.)
- Ken Dill and Sarina Bromberg, *Molecular Driving Forces* (2012 by Taylor and Francis Inc; 2nd edition)
- Daan Frenkel and Berend Smit, *Understanding Molecular Simulation* (2002 by Elsevier, 2nd edition)

Part of the Module: Method Course: Computational Biophysics (Practical Course)**Mode of Instruction:** internship**Language:** English / German**Contact Hours:** 4**Learning Outcome:**

- Students learn to solve typical biophysical problems analytically and numerically
- Students learn to run and analyze computer simulations of biological matter
- Students learn to visualization, documentation and presentation of results

Contents:

The methods and tools discussed in the lecture will be applied to typical biophysical problems and biological systems. The students work individually or in small teams under supervision. The students present their solutions, document their simulations and summarize their results in a final report.

Examination**Method Course: Computational Biophysics**

written exam / length of examination: 2 hours

Module PHM-0287: Method Course: Spectroscopy of Organic Semiconductors <i>Method Course: Spectroscopy of Organic Semiconductors</i>		8 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Wolfgang Brütting Dr. Alexander Hofmann		
Contents: <ul style="list-style-type: none"> • Growth and characterisation of thin films (vapor deposition, spin coating, surface profiling, atomic force microscopy) • Optical spectroscopy and photophysics (ellipsometry, transmission, steady-state and time-resolved photoluminescence, orientation anisotropy) • Charge transport (space-charge limited current, field-effect mobility, doping) • Light-emitting diodes (different emitter types, device efficiency measurement and simulation) • Solar cells (different device architectures, power and quantum efficiency measurements) 		
Learning Outcomes / Competences: The students <ul style="list-style-type: none"> • get familiar with the preparation of organic semiconductors as thin films and in devices and learn basic spectroscopic techniques to characterise them, • acquire skills to analyse properties of the materials taking into account their specific features, • and have the competence to comprehend and attend to current problems in the field of organic electronics. • Integrated acquirement of soft skills: practicing technical English, working with English specialist literature, ability to critically interpret experimental results. 		
Workload: Total: 240 h		
Conditions: Basic knowledge of atomic and solid state physics, as well as elementary concepts of quantum physics.		Credit Requirements: Bestehen der Modulprüfung
Frequency: annually	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Method Course: Spectroscopy of Organic Semiconductors Mode of Instruction: lecture Language: English / German Contact Hours: 2		
Lehr-/Lernmethoden: The basics for each topic will be taught in class, e.g. using black board and beamer presentation.		
Literature: <ul style="list-style-type: none"> • M. Schwoerer, H. Ch. Wolf: Organic Molecular Solids (Wiley-VCH) • A. Köhler, H. Bässler: Electronic Processes in Organic Semiconductors (Wiley-VCH) • S.R. Forrest: Organic Electronics (Oxford Univ. Press) 		
Assigned Courses: Method Course: Spectroscopy of Organic Semiconductors (internship)		

Part of the Module: Method Course: Spectroscopy of Organic Semiconductors (Practical Course)

Mode of Instruction: internship

Language: English / German

Contact Hours: 4

Lehr-/Lernmethoden:

After teaching in class, the students will go to the lab to get practical experience with each topic.

Assigned Courses:

Method Course: Spectroscopy of Organic Semiconductors (internship)

Examination

Method Course: Spectroscopy of Organic Semiconductors

report

Module PHM-0297: Method Course: Methods in Bioanalytics <i>Method Course: Methods in Bioanalytics</i>		8 ECTS/LP
Version 1.0.0 (since WS22/23) Person responsible for module: Prof. Dr. Janina Bahnemann		
Contents: <ul style="list-style-type: none"> - Basic concepts of instrumental analytics, sensor technology, validation, quality assurance - Biological basics for sensor design and sample components - Biological markers, biomaterials and targets: bioreceptors: antibodies, enzymes, aptamers, cells, nanoparticles - Sensor principles / transducers: optical, thermal, electrochemical, electromechanical, colorimetric - Sensor materials (e.g., silicon, gold, plastics, polymers) - Immobilization of bioreceptors on sensor materials - Lateral flow assays, Point-of-Care diagnostics - Carbohydrate and lipid analysis: Chromatographic methods (HPLC, GC, DC, MS) - Amino acid analytics: HPLC, fluorescence spectroscopy - Nucleic acid analytics: PCR method, sequencing, electrophoresis, microarrays - Protein analytics: Chromatography, electrophoresis, spectroscopy, Bradford assay - Cell analytics: Flow cytometry and microscopy - Concepts and materials for sensor development and optimization: e.g., Microfluidics, additive manufacturing, nanoporous materials, nanoparticles, amplifiers 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • Students will be able to use acquired analytical expertise to adequately describe and correlate basic principles of bioanalysis and their applications. • Students will be able to transfer acquired knowledge from the lecture to practical applications in the experimental practical course. • Students will demonstrate self-competence of work organization as well as social competence by working in small groups. • Students will learn to identify proteins using various analytical methods, to set up biosensors for measuring glucose concentrations, and to scientifically evaluate, comprehensibly record in writing, and present the practical results. 		
Remarks: ELECTIVE COMPULSORY MODULE Number of students will be limited to 9.		
Workload: Total: 240 h		
Conditions: keine / none		Credit Requirements: Practical work and written report
Frequency: nach Bedarf WS und SoSe	Recommended Semester: 1. - 4.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: none	

Parts of the Module
Part of the Module: Method Course: Methods in Bioanalytics Language: German / English Contact Hours: 2
Literature: <ul style="list-style-type: none">• Lottspeich and Engels: "Bioanalytik", Spektrum Akademischer Verlag, ISBN: 3-8274-2942-0• Lottspeich and Engels: "Bioanalytics: Analytical Methods and Concepts in Biochemistry and Molecular Biology"• Ozkan et al.: "Biosensors: Fundamentals, Emerging Technologies, and Application", CRC Press• Yoon: "Introduction to Biosensors: From Electric Circuits to Immunosensors", Springer Verlag, ISBN: 978-3319801360• Thieman: "Introduction to Biotechnology", Pearson, ISBN: 978-1292261775
Assigned Courses: Method Course: Methods in Bioanalytics
Part of the Module: Method Course: Methods in Bioanalytics (Practical Course) Language: German / English Contact Hours: 4
Assigned Courses: Method Course: Methods in Bioanalytics
Examination Method Course: Methods in Bioanalytics report, Practical work and written report on practical work

Module PHM-0298: Method course: From macroscopic to microscopic ferroic properties <i>Method course: From macroscopic to microscopic ferroic properties</i>		8 ECTS/LP
Version 1.0.0 (since WS22/23) Person responsible for module: Prof. Dr. István Kézsmárki		
<p>Contents:</p> <p>Within this course, the students will learn the basic concepts of ferroic properties, e.g. ferroelectricity and ferromagnetism, which play a key role in materials science and engineering, at cryogenic temperatures. This method course will teach the students to understand and perform experiments on ferroic materials first, on a macroscopic scale and, after having a fundamental understanding, microscopic measurements. Therefore, the students will be taught in preparing single crystals, planning complex measurement procedures, and evaluating the measured data.</p> <p>Magnetic Properties will be investigated via:</p> <ul style="list-style-type: none"> • Magnetization measurements • Susceptibility measurements • Magnetic force microscopy (MFM) <p>Electric Properties will be investigated via:</p> <ul style="list-style-type: none"> • Linear and non-linear dielectric spectroscopy • SEM / EDX • Polarization measurements • Conductive atomic force microscopy (cAFM) / piezo force microscopy (PFM) 		
<p>Learning Outcomes / Competences:</p> <ul style="list-style-type: none"> • fundamental knowledge of properties in electric and magnetic materials • instruction in experimental methods for investigation of ferroic properties of condensed matter • perform experiments at cryogenic temperatures • trained in planning and performing complex experiments • learn to evaluate and analyze the collected data • combining knowledge of macroscopic measurements to understand microscopic data to fully understand electric and magnetic properties 		
<p>Remarks: ELECTIVE COMPULSORY MODULES</p>		
<p>Workload: Total: 240 h</p>		
<p>Conditions: Recommended: basic knowledge in solid state physics and ferroic properties</p>		<p>Credit Requirements: Participation in laboratory course and oral examination.</p>
<p>Frequency: each semester</p>	<p>Recommended Semester:</p>	<p>Minimal Duration of the Module: 1 semester[s]</p>
<p>Contact Hours: 6</p>	<p>Repeat Exams Permitted: according to the examination regulations of the study program</p>	
<p>Parts of the Module</p>		
<p>Part of the Module: Method course: From macroscopic to microscopic ferroic properties Language: English Contact Hours: 2</p>		

Literature:

- N.W. Ashcroft, N.D. Mermin, Festkörperphysik (Oldenbourg)
- Ch. Kittel, Einführung in die Festkörperphysik (Oldenbourg)
- V. K. Wadhawan, Introduction to ferroic materials (CRC Press)
- S. Kalinin, A. Gruverman, Scanning Probe Microscopy - Electrical and electromechanical phenomena at the nanoscale (Springer)
- A. K. Tagantsev, Domains in Ferroic Crystals and Thin films (Springer)

Assigned Courses:

Method course: From macroscopic to microscopic ferroic properties (lecture)

Part of the Module: Method course: From macroscopic to microscopic ferroic properties (Practical Course)

Language: English

Contact Hours: 4

Assigned Courses:

Method course: From macroscopic to microscopic ferroic properties (lecture)

Examination

Method course: From macroscopic to microscopic ferroic properties

oral exam / length of examination: 45 minutes

Module PHM-0254: Laboratory Project (MSE)		10 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Ferdinand Haider		
Contents: Experimental or theoretical work in a laboratory / research group in the Institute of Physics or in the Institute for Materials Resource Management. Has to be conducted within 3 months and must be approved by a teaching person.		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic terms, skills and concepts to pursue a real research project in the existing laboratories within the research groups, • experience the day to day life in a research group from within, • prepare themselves to conduct a research project during their Masters thesis. • acquire the technical skills necessary to start their Masters thesis • Learn to search for relevant literature, to work with it and to refer properly to it 		
Conditions: Recommended: solid knowledge in (solid state) Physics, Chemistry and Materials Science, both experimentally and theoretically		Credit Requirements: 1 written report (editing time 2 weeks)
Frequency: each semester	Recommended Semester:	Minimal Duration of the Module: semester[s]
	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Laboratory Project Mode of Instruction: internship Language: English		
Examination Laboratory Project project work		

Module PHM-0255: Internship		10 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Ferdinand Haider		
Conditions: none		
Frequency:	Recommended Semester:	Minimal Duration of the Module: semester[s]
	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Internship Language: English / German		

Module ZCS-6601: Softskill-Kurse - Kommunikationskompetenz		2 ECTS/LP
Version 1.2.0 (since WS16/17) Person responsible for module: Prof. Dr. Andreas Rathgeber Claudia Lange-Hetmann		
Contents: Die Studierenden erwerben in den Softskill-Kursen, die diesem Modul zugeordnet sind, primär kommunikative Fähigkeiten, die unerlässlich für ihre künftige Berufsfähigkeit sind. Zudem bildet die interdisziplinäre Zusammensetzung der Teilnehmer aus unterschiedlichen Fachrichtungen den typischen Wirkungskreis von Wirtschaftsingenieuren ab. Detailbeschreibungen zu Kursen und Anmeldeverfahren befinden sich auf https://www.uni-augsburg.de/de/studium/zusatzqualifikationen/profilbildung/#Anker_skK bzw. im digicampus.		
Learning Outcomes / Competences: Die Studierenden können, neben dem Erwerb der Fertigkeit der verständlichen, sicheren und überzeugenden Darbietung von Ihren Ideen, Konzepten und Ergebnissen bzw. dem Verständnis der psychologischen Grundlagen von Dialogen und Verhandlungen, dieses Wissen anwenden, um Interesse, Verständlichkeit und Sympathie zu erzeugen und zielorientiert zu präsentieren bzw. zu argumentieren. Sie verstehen die Kommunikations-, Dialog- und Teamprozesse in Bezug auf Motivation und Effektivität und können Moderationstechniken und ihre Fertigkeit zur Selbstreflexion anwenden und sind befähigt, diese in einen neuen Kontext zu transferieren. Die interdisziplinäre Herangehensweise eines Wirtschaftsingenieurs an eine Problemstellung wird durch die interdisziplinäre Zusammensetzung der Kleingruppen in den Kursen trainiert, durch praktische Übungen in den Kursen gefestigt und durch Selbstreflexion und Feedbackmethoden verinnerlicht.		
Remarks: Anmeldepflicht: Für die Teilnahme an den Kursen ist eine Anmeldung über digicampus erforderlich. Anmeldephase: Januar (für das folgende SS) bzw. Juli (für das folgende WS) - genaue Termine im digicampus. Die Kurse finden größtenteils ab Mitte März bis letzten Sa* im April (SS) bzw. ab Mitte Sep. bis letzten Sa* im Okt. statt. (*vor Vorlesungsbeginn). Die Kurse haben eine limitierte Teilnehmerzahl pro Semester. Für das Modul D: Softskills können die verschiedenen Module ZCS-610x "Softskill-Kurstage <Kom/Soz/MethKompetenz> und ZCS-6601 "Softskill-Kurse <Kom/Soz/MethKompetenz> variabel kombiniert werden sowie mit Angeboten der vhb-Kurse und Auslandsleistungen ergänzt werden, um die 6 ECTS zu erreichen. Es empfiehlt sich ab dem 3. Semester jedes Semester einen Kurs zu belegen oder in einem Semester einen der Kompaktkurse.		
Workload: Total: 60 h 10 h studying of course content using literature (self-study) 10 h studying of course content through exercises / case studies (self-study) 10 h studying of course content using provided materials (self-study) 20 h (attendance) 10 h preparation of presentations (self-study)		
Conditions: none		Credit Requirements: aktive Übungsteilnahme im Kurs plus Prüfung mit min. Note 4,0 (bestanden).
Frequency: each semester	Recommended Semester: from 3.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 2	Repeat Exams Permitted: according to the examination regulations of the study program	

<p>Parts of the Module</p>
<p>Part of the Module: Softskill-Kurse - Kommunikationskompetenz</p> <p>Mode of Instruction: seminar</p> <p>Language: German</p> <p>Contact Hours: 2</p> <p>ECTS Credits: 2.0</p>
<p>Contents:</p> <p>Themen, die (un)regelmäßig angeboten werden sind:</p> <ul style="list-style-type: none"> - Kommunikationstraining - Rhetorik - Strategische Gesprächsführung - erfolgreiche Moderation und Präsentation - erfolgreich Debattieren - Kommunikation in Projekten <p>sowie</p> <ul style="list-style-type: none"> - Teams führen - Konfliktmanagement - Emotionale Intelligenz <p>Weitere Informationen finden sich unter https://www.uni-augsburg.de/de/studium/zusatzqualifikationen/profilbildung/ bzw. im digicampus.</p>
<p>Lehr-/Lernmethoden:</p> <p>Vortrag / Präsentation mittels Tafel / Flipchart / Pinwand / Beamer, interaktive Übungen, Gruppenarbeit, Diskussion, Reflexion</p>
<p>Literature:</p> <p>wird in den Kursbeschreibungen angegeben bzw. vorab kommuniziert.</p>
<p>Assigned Courses:</p> <p>Kurs Erfolgreich Debattieren (course)</p> <p>Kurs Erfolgreich in Moderation und Präsentation (course)</p> <p>Kurs Kommunikationstraining (course)</p> <p>Kurs Rhetorik (course)</p> <p>Kurs Rhetorik (Jan) (course)</p> <p>Kurs Strategische Gesprächsführung (course)</p> <p>Kurs Strategische Gesprächsführung (Nov) (course)</p>
<p>Examination</p> <p>Kombinierte Prüfung Softskill-Kurse</p> <p>module exam, Praxisleistung (Referat/Präsentation/Projektarbeit - im Kurs) oder eine schriftliche/mündliche Prüfungsleistung (mündliche Kurz-Prüfung/ Klausur/ Seminararbeit - 30 min) am Ende bzw. direkt nach dem Kurs abzuleisten / length of examination: 30 minutes</p>

Module ZCS-6602: Softskill-Kurse - Sozialkompetenz		2 ECTS/LP
Version 1.1.0 (since WS16/17) Person responsible for module: Prof. Dr. Andreas Rathgeber Claudia Lange-Hetmann		
Contents: Die Studierenden trainieren in diesem Modul primär Fähigkeiten für die soziale Interaktion, die unerlässlich für ihre künftige Berufsfähigkeit sind, denn diese fordert eine überzeugende Persönlichkeit des Einzelnen und eine einwandfreie und zielgerichtete Interaktion im Team. Zudem bildet die interdisziplinäre Zusammensetzung der Teilnehmer aus unterschiedlichen Studienrichtungen den typischen Wirkungskreis von Wirtschaftsingenieuren ab. Detailbeschreibungen zu Kursen und Anmeldeverfahren befinden sich auf https://www.uni-augsburg.de/de/studium/zusatzqualifikationen/profilbildung/#Anker_skK bzw. im digicampus.		
Learning Outcomes / Competences: Die Studierenden verstehen die Kommunikations-, Dialog- und Teamprozesse in Bezug auf Motivation, Effektivität. Sie erkennen die Entstehung, Dynamik, Lösung und Prävention von Konflikten, können Moderations- und Präsentationstechniken und ihre Fertigkeit zur Selbstreflexion anwenden, sie beherrschen die Regeln bei der Teamarbeit, bei Besprechungen bis hin zur Führung von Teams oder sie verstehen den Nutzen von gesellschaftlichem Engagement und nachhaltigem Wirtschaften für sich, für Unternehmen und für die Gesellschaft und sind befähigt nachhaltige Konzepte zu entwickeln. Die interdisziplinäre Herangehensweise an eine Problemstellung wird durch die heterogene Zusammensetzung der Kleingruppen in den Kursen trainiert, durch praktische Übungen in den Kursen gefestigt und durch Selbstreflexion und Feedbackmethoden verinnerlicht, um den Transfer auf neue Situationen zu gewährleisten.		
Remarks: Anmeldepflicht: Für die Teilnahme an den Kursen ist eine Anmeldung über digicampus erforderlich. Anmeldephase: Januar (für das folgende SS) bzw. Juli (für das folgende WS) - genaue Termine siehe digicampus. Die Kurse finden größtenteils ab Mitte März bis letzten Sa* im April (SS) bzw. ab Mitte Sep. bis letzten Sa* im Okt. statt. (*vor Vorlesungsbeginn). Die Kurse haben eine limitierte Teilnehmerzahl pro Semester. Für das Modul D: Softskills können die verschiedenen Module ZCS-610x "Softskill-Kurstage <Kom/Soz/MethKompetenz> und ZCS-6601 "Softskill-Kurse <Kom/Soz/MethKompetenz> variabel kombiniert werden sowie mit Angeboten der vhb-Kurse und Auslandsleistungen ergänzt werden, um die 6 ECTS zu erreichen. Es empfiehlt sich ab dem 3. Semester jedes Semester einen Kurs zu belegen oder in einem Semester einen der Kompaktkurse.		
Workload: Total: 60 h 20 h seminar (attendance) 20 h (self-study) 20 h studying of course content using literature (self-study)		
Conditions: none		Credit Requirements: aktive Übungsteilnahme im Kurs plus Prüfung mit min. Note 4,0 (bestanden).
Frequency: each semester	Recommended Semester: from 3.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 1	Repeat Exams Permitted: according to the examination regulations of the study program	

<p>Parts of the Module</p>
<p>Part of the Module: Softskill-Kurse - Sozialkompetenz</p> <p>Mode of Instruction: course Language: German Contact Hours: 2 ECTS Credits: 2.0</p>
<p>Contents:</p> <p>Themen, die (un)regelmäßig angeboten werden sind:</p> <ul style="list-style-type: none"> - Konfliktmanagement - Moderation & Teamleitung - Emotionale Intelligenz - Teams führen - Führung erleben - Führungskompetenzen entwickeln - Gesellschaftliches Engagement <p>sowie</p> <ul style="list-style-type: none"> - Strategische Gesprächsführung - Zeit-/Selbstmanagement - Changemanagement - Innovationen entwickeln - Design Thinking - Projektmanagement <p>Weitere Informationen finden sich unter https://www.uni-augsburg.de/de/studium/zusatzqualifikationen/profilbildung/ bzw. im digicampus.</p>
<p>Lehr-/Lernmethoden:</p> <p>Vortrag / Präsentation sowie interaktive Übungen - Medien Beamer / Flipchart / Pinwand, interaktive Übungen, Gruppenarbeit, Diskussion, Reflexion</p>
<p>Literature:</p> <p>wird im Kurs bz. in die Kursbeschreibungen angeben bzw. vorab kommuniziert.</p>
<p>Assigned Courses:</p> <p>ENTFÄLLT KRANKHEITSBEDINGT: Kurs Emotionale Intelligenz (Opt. 1) (course)</p> <p>Kurs Changemanagement (course)</p> <p>Kurs Corporate Responsibility und Nachhaltigkeitsmanagement (course)</p> <p>Kurs Emotionale Intelligenz (Opt. 2) (course)</p> <p>Kurs Emotionale Intelligenz (Opt. 3) (course)</p> <p>Kurs Führung erleben (course)</p> <p>Kurs Konfliktmanagement (Opt1) (course)</p> <p>Kurs Konfliktmanagement (Opt2) (course)</p> <p>Kurs Nachhaltiges Wirtschaften (course)</p> <p>Kurs Teams führen (course)</p>
<p>Examination</p> <p>Kombinierte Prüfung - Softskill-Kurse</p> <p>part-module exam, Praxisleistung (Referat/Präsentation/Projektarbeit - 10 min im Kurs) und eine schriftliche/mündliche Kurz-/Prüfungsleistung (mündliche Prüfung/ Klausur/ Seminararbeit - 20 min) am Ende bzw. direkt nach dem Kurs abzuleisten / length of examination: 30 minutes</p>

Module ZCS-6603: Softskill-Kurse - Methodenkompetenz		2 ECTS/LP
<p>Version 1.1.0 (since WS16/17) Person responsible for module: Prof. Dr. Andreas Rathgeber Claudia Lange-Hetmann</p>		
<p>Contents: Die Studierenden erwerben in den Softskill-Kursen, die diesem Modul zugeordnet sind primär methodische Fähigkeiten, die unerlässlich für ihre künftige Berufsfähigkeit sind. Zudem bildet die interdisziplinäre Zusammensetzung der Teilnehmer aus unterschiedlichen Fachrichtungen den typischen Wirkungskreis von Wirtschaftsingenieuren ab. Detailbeschreibungen zu Kursen und Anmeldeverfahren befinden sich auf https://www.uni-augsburg.de/de/studium/zusatzqualifikationen/profilbildung/#Anker_skK bzw. im digicampus.</p>		
<p>Learning Outcomes / Competences: Die Studierenden verstehen grundlegende Konzepte des Projektmanagements und können die Grundlagen der Motivationspsychologie und zentrale Führungstechniken zur Erreichung des Projekterfolgs anwenden. Oder sie können grundlegende Strategien und Methoden für die Entwicklung und Absicherung einer Unternehmensführung anwenden oder sie können Kreativitätstechniken anwenden, verstehen Probleme zu analysieren und können konstruktiv im Team eine Lösung erarbeiten und kompetenz kommunizieren. Sie beherrschen die Regeln bei Besprechungen und Moderationstechniken und können ihre Fertigkeit zur Selbstreflexion anwenden und auf neue Aufgabenstellungen transferieren. Die interdisziplinäre Herangehensweise an eine Problemstellung wird durch die heterogene Zusammensetzung der Kleingruppen in den Kursen trainiert, durch praktische Übungen in den Kursen gefestigt und durch Selbstreflexion und Feedbackmethoden verinnerlicht, um den Transfer auf neue Situationen zu gewährleisten.</p>		
<p>Remarks: Anmeldungspflicht: Für die Teilnahme an den Kursen ist eine Anmeldung über das VV (Theoretische Informatik) erforderlich. Anmeldephase: bzw. Juli . Die Kurse haben eine limitierte Teilnehmerzahl pro Semester. Für das Modul D: Softskills können die verschiedenen Module ZCS-610x "Softskill-Kurstage <Kom/Soz/ MethKompetenz> und ZCS-6601 "Softskill-Kurse <Kom/Soz/MethKompetenz> variabel kombiniert werden sowie mit Angeboten der vhb-Kurse und Auslandsleistungen ergänzt werden, um die 6 ECTS zu erreichen. Es empfiehlt sich ab dem 3. Semester jedes Semester einen Kurs zu belegen oder in einem Semester einen der Kompaktkurse.</p>		
<p>Workload: Total: 60 h 20 h seminar (attendance) 10 h studying of course content using literature (self-study) 10 h studying of course content using provided materials (self-study) 20 h (self-study)</p>		
<p>Conditions: none</p>		<p>Credit Requirements: aktive Übungsteilnahme im Kurs plus Prüfung mit min. Note 4,0 (bestanden).</p>
<p>Frequency: each semester</p>	<p>Recommended Semester: from 3.</p>	<p>Minimal Duration of the Module: 1 semester[s]</p>
<p>Contact Hours: 1</p>	<p>Repeat Exams Permitted: according to the examination regulations of the study program</p>	

Parts of the Module
Part of the Module: Softskill-Kurse - Methodenkompetenz Language: German / English
Contents: Kurse die (un)regelmäßig angeboten werden: - Zeit-/Selbstmanagement - Changemanagement - Design Thinking - Projektmanagement (dt. / engl.) - Unternehmerisches Denken sowie - Innovationen entwickeln - nachhaltig Wirtschaften - Corporate Responsibility und Nachhaltigkeit Weitere Informationen finden sich im digicampus.
Literature: wird im Kurs bz. in die Kursbeschreibungen angeben bzw. vorab kommuniziert.
Assigned Courses: Kurs Innovationen entwickeln (course) Kurs Projektmanagement (Opt1) (course) Kurs Projektmanagement (Opt2) (course) Kurs Unternehmerisch Denken - Planspiel Startup (course)
Examination Kombinierte Prüfung Softskill-Kurse part-module exam, pro Teilmodul ist - je eine Praxisleistung (Referat/Präsentation/Projektarbeit - 10 min im Kurs) und je eine schriftliche/mündliche Prüfungsleistung (mündliche Kurz-/Prüfung/ Klausur/ Seminararbeit - 20 min) am Ende bzw. direkt nach dem Kurs abzuleisten / length of examination: 30 minutes

Module PHM-0283: Masterthesis <i>Masterthesis</i>		26 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Ferdinand Haider		
Contents: According to chosen topic		
Learning Outcomes / Competences: Students work in a research group on an advanced scientific problem learn to solve daily experimental or theoretical problems learn to perform search for actual scientific literature, to review it critically and to properly cite it in the written version have to integrate in a research group, interact with other members of the group, present their actual results in and outside the group		
Remarks: COMPULSORY MODULE		
Workload: Total: 780 h 520 h (self-study) 260 h studying of course content using provided materials (self-study)		
Conditions: The Master's thesis can be started at the earliest after the successful completion of the modules from module groups 1 (or FMI-First Year) and 7 and the acquisition of at least 78 credit points. Recommended: according to the respective advisor		Credit Requirements: written thesis
Frequency: each semester	Recommended Semester: from 4.	Minimal Duration of the Module: 1 semester[s]
	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Masterthesis		
Language: English / German		
Learning Outcome: see description of module		
Contents: see description of module		
Examination		
Masterthesis Master's thesis		

Module PHM-0284: Colloquium <i>Colloquium</i>		4 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Ferdinand Haider		
Contents: According to the respective Masterthesis		
Learning Outcomes / Competences: Prepare a scientific presentation to the thesis supervisors and, if desired, to a wider audience learn to setup a presentation reflecting the major results of the thesis learn to properly reply to questions regarding the presentation and the background of the master thesis		
Remarks: COMPULSORY MODULE		
Workload: Total: 120 h 40 h studying of course content using provided materials (self-study) 80 h (self-study)		
Conditions: submission of the masterthesis		
Frequency: each semester Siehe Bemerkungen	Recommended Semester: from 4.	Minimal Duration of the Module: 1 semester[s]
	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Colloquium		
Language: English		
Learning Outcome: see description of module		
Contents: see description of module		
Examination		
Colloquium oral exam, approx. 30 to 40-minute presentation of the contents of the master's thesis followed by a discussion		

Module PHM-0209: Functional Materials (International) – first year (Institut National Polytechnique de Grenoble) <i>Functional Materials (International) – first year (Institut National Polytechnique de Grenoble)</i>		62 ECTS/LP
Version 1.0.0 (since WS16/17) Person responsible for module: Prof. Dr. Ferdinand Haider		
Conditions: studies at an international partner institution		Credit Requirements: written exam, oral exam, report, etc.
Frequency: each semester	Recommended Semester:	Minimal Duration of the Module: semester[s]
	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Functional Materials (International) – (Foreign Institution) Language: English		
Examination Functional Materials (International) – (Foreign Institution) module exam, written exam, oral exam, report, etc.		

Module MRM-0025: Fiber Reinforced Polymers for Engineers <i>Faserverbundkunststoffe - Produktion und Anwendung</i>		6 ECTS/LP
Version 1.0.0 (since WS15/16) Person responsible for module: Prof. Dr.-Ing. Michael Kupke		
Learning Outcomes / Competences: Die Studierenden - kennen die Vor- und Nachteile von Faserverbundwerkstoffen in Herstellung und Anwendung - haben ein Verständnis über faserverbundgerechte Bauweisen - kennen das Prinzip der Bauweisenbewertung für das Produkt		
Remarks: Ansprechpartnerin: Prof. Dr.-Ing. Michael Kupke, Tobias Karrasch (tobias.karrasch@mrm.uni-augsburg.de)		
Workload: Total: 180 h		
Conditions: none		Credit Requirements: Schriftliche Prüfung
Frequency: each semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 2	Repeat Exams Permitted: any	
Parts of the Module		
Part of the Module: Faserverbundkunststoffe für Ingenieure Mode of Instruction: lecture Lecturers: Prof. Dr.-Ing. Michael Kupke Language: German Contact Hours: 2		
Contents: 1. Grundlagen 2. Herstellung 3. Produktion 4. Anwendung		
Lehr-/Lernmethoden: Tafelanschrift und Beamerpräsentation		
Literature: wird in der Vorlesung bekannt gegeben		
Assigned Courses: Faserverbundkunststoffe – Produktion und Anwendung (Faserverbundkunststoffe für Ing.) (lecture)		
Examination Faserverbundkunststoffe für Ingenieure written exam, Schriftliche Prüfung		

Module MRM-0120: Materials for lightweight construction <i>Werkstoffe für den Leichtbau</i>		6 ECTS/LP
Version 1.0.0 (since SoSe19) Person responsible for module: Prof. Dr.-Ing. Kay Weidenmann		
Learning Outcomes / Competences: Die Studierenden sind in der Lage verschiedene Leichtbauwerkstoffe zu benennen und deren Zusammensetzungen, Eigenschaften und Einsatzgebiete zu beschreiben. Sie können die für Leichtbauwerkstoffen wesentlichen werkstoffkundlichen Mechanismen zur Festigkeitssteigerung von Leichtbauwerkstoffen beschreiben und können diese anwendungsorientiert übertragen. Die Studierenden können einfache mechanische Modelle von Verbundwerkstoffen anwenden und können Unterschiede im mechanischen Verhalten in Abhängigkeit von Zusammensetzung und Aufbau aufzeigen. Die Studierenden können das Prinzip hybrider Werkstoffkonzepte erläutern und können deren Vorteile im Vergleich von Vollwerkstoffen bewerten. Die Studierenden können Sonderwerkstoffe des Leichtbaus benennen und die Unterschiede zu konventionellen Leichtbauwerkstoffen aufzeigen. Die Studierenden sind in der Lage, Anwendungen für die einzelnen Werkstoffe aufzuzeigen und deren Einsatz abzuwägen.		
Remarks: Im Rahmen der Veranstaltung findet eine verpflichtende Exkursion statt.		
Workload: Total: 180 h		
Conditions: Grundlagenwissen im Bereich Materialwissenschaften auf Bachelorniveau.		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 3	Repeat Exams Permitted: any	
Parts of the Module		
Part of the Module: Werkstoffe für den Leichtbau Mode of Instruction: lecture Language: German Contact Hours: 2		

Contents:

- Einführung
- Konstruktive, fertigungstechnische und werkstoffkundliche Aspekte des Leichtbaus
- Aluminiumbasislegierungen
 - Aluminiumknetlegierungen
 - Aluminiumgusslegierungen
- Magnesiumbasislegierungen
 - Magnesiumknetlegierungen
 - Magnesiumgusslegierungen
- Titanbasislegierungen
 - Titanknetlegierungen
 - Titangusslegierungen
- Hochfeste Stähle
 - Hochfeste Baustähle
 - Vergütungsstähle und aushärtbare Stähle
- Verbundwerkstoffe, insbesondere mit polymerer Matrix
 - Matrizen
 - Verstärkungselemente
- Hybride Werkstoffe
 - Grundprinzipien
 - Werkstoffsysteme
 - Funktionstrennung
- Sonderwerkstoffe
 - Beryllium
 - Metallische Gläser
- Anwendungen

Literature:

Literaturhinweise, Unterlagen und Teilmanuskript in der Vorlesung

Part of the Module: [Exkursion zu Werkstoffe für den Leichtbau](#)

Mode of Instruction: excursion

Language: German

Contact Hours: 1

Examination

Werkstoffe für den Leichtbau

oral exam

Module MRM-0126: Ceramic Matrix Composites <i>Keramische Faserverbundwerkstoffe</i>		6 ECTS/LP
Version 3.0.0 (since WS21/22) Person responsible for module: Prof. Dr.-Ing. Dietmar Koch		
Contents: <ul style="list-style-type: none"> • Introduction in ceramic matrix composites • Basics of processing of technical ceramics • Processing chain of ceramic matrix composites (CMC) from raw materials to product • Processing and properties of ceramic fibers • Principal mechanisms of reinforcement in CMC • Properties of CMC • Application of CMC 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students know the basic concepts of mechanical behavior of ceramic matrix composites • The students have the competence to explain processing of ceramic fibers and ceramic matrix composites and describe their specific properties • The students know the Weibull statistics which describe the fiber strength distribution • The students know how to describe mechanical interactions between fiber and matrix • The students get the knowledge of application of ceramic matrix composites and are able to choose the according material for specific application. • The students acquire scientific skills to search for scientific literature and to evaluate scientific content 		
Workload: Total: 180 h 120 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Recommended: basic knowledge of materials		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Keramische Faserverbundwerkstoffe		
Mode of Instruction: lecture		
Language: English		
Contact Hours: 3		
Learning Outcome: see description of module		
Contents: see description of module		

Literature:

- N.P. Bansal, J. Lamon, Ceramic Matrix Composites: Materials, Modeling and Technology. John Wiley & Sons, Inc., 2015.
- W. Krenkel, Ceramic Matrix Composites. Wiley-VCH Verlag GmbH & Co. KGaA, 2008.
- K. K. Chawla, Composite Materials 3rd ed., Springer, 2012
- T. Ohji, M. Singh, Engineered Ceramics: Current Status and Future Prospects, ISBN: 978-1-119-10042-3, 2015

Assigned Courses:

Keramische Faserverbundwerkstoffe (lecture)

Examination

Keramische Faserverbundwerkstoffe

written exam, written exam / length of examination: 60 minutes

Parts of the Module

Part of the Module: Übung Keramische Faserverbundwerkstoffe

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Learning Outcome:

see description of module

Contents:

see description of module

Literature:

see description of module

Assigned Courses:

Keramische Faserverbundwerkstoffe (lecture)

Module MRM-0128: Bioinspired Composites <i>Bioinspired Composites</i>		6 ECTS/LP
Version 2.0.0 (since WS20/21) Person responsible for module: Prof. Dr.-Ing. Dietmar Koch		
Contents: <ul style="list-style-type: none"> • Introduction in bionics and bioinspiration • Basics of bionic principles • Fundamental approaches to develop technical components based on bioinspired ideas • Topology optimization • Bioinspired ceramic and polymer based components • Natural fiber based bioinspired materials • Application of bioinspired materials 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students know the basic principles of bionics and bioinspiration • The students know the bionically motivated development of technical components • The students have the competence to explain topology optimization • The students understand general principles bioinspired composites • The students get the knowledge about manufacturing, properties and application of natural fiber based composites • The students acquire scientific skills to search for scientific literature and to evaluate scientific content 		
Workload: Total: 180 h 120 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance)		
Conditions: basic knowledge of material science		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Bioinspired Composites Mode of Instruction: lecture Lecturers: Prof. Dr.-Ing. Dietmar Koch Language: English / German Frequency: each summer semester Contact Hours: 3		
Contents: see description of module		

<p>Literature:</p> <ul style="list-style-type: none"> • B. Arnold, Werkstofftechnik für Wirtschaftsingenieure. 1. Auflage, Springer Verlag (2013) • W. Bobeth (Ed.), Textile Faserstoffe - Beschaffenheit und Eigenschaft, Springer-Verlag (1993) • W. Nachtigal, K. G. Blüchel, Das große Buch der Bionik – Neue Technologien nach dem Vorbild der Natur. 2. Auflage, Deutsche Verlags-Anstalt (2001) • C. Hamm (Ed.), Evolution of Light Weight Structures - Analyses and Technical Applications, Springer-Verlag (2015) • J. Müssig (Ed.), C. V. Stevens (Series Ed.), Industrial Applications of Natural Fibres: Structure, Properties and Technical Applications, Wiley Series in Renewable Resources (2010)
<p>Examination</p> <p>Bioinspired Composites</p> <p>written exam, written exam / length of examination: 60 minutes</p>
<p>Parts of the Module</p> <p>Part of the Module: Übung Bioinspired Composites</p> <p>Mode of Instruction: exercise course</p> <p>Language: German</p> <p>Frequency: each summer semester</p> <p>Contact Hours: 1</p>
<p>Learning Outcome:</p> <p>see description of module</p>
<p>Contents:</p> <p>see description of module</p>
<p>Literature:</p> <p>see description of module</p>

Module MRM-0136: Mechanical Characterization of Materials <i>Mechanical Characterization of Materials</i>		6 ECTS/LP
Version 1.1.0 (since SoSe21) Person responsible for module: Prof. Dr. Markus Sause		
Contents: The following topics are presented: <ul style="list-style-type: none"> • Introduction to material characterization • Linear material behaviour • Non-linear material behaviour • Material failure • Measurement technologies • Tensile testing • Compression testing • Shear testing • Other static testing concepts • Fracture mechanics • Assembly testing • Surface mechanics • Creep testing • Fatigue testing • High-Velocity testing • Component testing 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • Acquire knowledge in the field of materials testing and evaluation of materials. • Are introduced to important concepts in measurement techniques, and material models. • Are able to independently acquire further knowledge of the scientific topic using various forms of information. 		
Workload: Total: 180 h 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 60 h lecture and exercise course (attendance)		
Conditions: None		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Mechanical Characterization of Materials Mode of Instruction: lecture Language: English Contact Hours: 3		

Literature:

- Issler, L., & Häfele, H. R. P. (2003). Festigkeitslehre — Grundlagen. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-540-73485-7>
- Dowling, N. E. (2019). Mechanical Behavior of Materials (4th ed.). Pearson.
- Gross, D., & Seelig, T. (2011). Fracture Mechanics. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-642-19240-1>
- J. Schijve. (2008). Fatigue of Structures and Materials (2nd Edition). Springer Science & Business Media.
- Sadd, M. H. (2018). Continuum Mechanics Modeling of Material Behavior. In Continuum Mechanics Modeling of Material Behavior. Elsevier. <https://doi.org/10.1016/C2016-0-01495-X>

Examination

Mechanical Characterization of Materials

written exam, written exam / length of examination: 90 minutes

Parts of the Module

Part of the Module: Mechanical Characterization of Materials (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Module MRM-0142: Complex 3D Structures and Components from 2D Materials <i>Complex 3D Structures and Components from 2D Materials</i>	6 ECTS/LP
Version 1.0.0 Person responsible for module: Prof. Dr.-Ing. Suelen Barg	
<p>Contents:</p> <p>Introduction:</p> <ul style="list-style-type: none"> • Complex Materials in Nature • Motivations in assembling 2D Materials in 3D with an overview of their demands for future technological applications (from energy to aerospace) <p>Nano and 2D Materials:</p> <ul style="list-style-type: none"> • Introduction to nano and 2D Materials • Scaling laws and the evolution of properties with size • Graphene structure, properties, and characterization • 2D Transition Metal Carbides (MXenes) • 2D Materials synthesis routes: top-down and bottom-up approaches <p>From 2D to 3D:</p> <ul style="list-style-type: none"> • Motivations, Challenges, and opportunities • Colloidal processing routes with 2D Materials: Principles of wet processing • Self-assembly, templating, and additive manufacturing (AM) routes • Extrusion-based AM with 2D Materials • Functionalities and Applications • Aerogel supports for functional composite development • 3D architectures for energy storage 	
<p>Learning Outcomes / Competences:</p> <p>By completing this unit, the students should be able to:</p> <p>Knowledge and understanding:</p> <ul style="list-style-type: none"> • Define the classes of nanomaterials depending on their dimensionality. • Identify the different families of 2D materials beyond graphene, including transition metal dichalcogenides (TMDs), carbides and/or nitrides (MXenes). • Summarize top-down and bottom-up synthesis strategies towards 2D materials. • Select appropriate syntheses routes for a given application based on property requirements and cost efficiency of the approach. • Explain the basic principles, advantages and disadvantages of innovative colloidal processing routes applied to 2D materials-based 3D structures. <p>Intellectual skills:</p> <ul style="list-style-type: none"> • Solve problems involving the evolution of properties with size in nanomaterials by the application of simple spherical cluster approximation models. • Evaluate the effect of microstructure and composition to develop new materials properties and/or control device efficiency using real examples from the literature. <p>Transferable and practical skills:</p> <ul style="list-style-type: none"> • Evaluate English language scientific content in the specialist literature. • Apply analytical methods to solve problems. 	
<p>Workload:</p> <p>Total: 180 h</p>	

Conditions: materials science basic knowledge		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Complex 3D Structures and Components from 2D Materials		
Mode of Instruction: lecture		
Lecturers: Prof. Dr.-Ing. Suelen Barg		
Language: English		
Contact Hours: 4		
Learning Outcome: See description of the module		
Contents: See description of the module		
Literature: <ul style="list-style-type: none"> • Sulabha K Kulkarni, Nanotechnology: principles and Practice, 3rd Ed., 2015 (Springer-Verlag GmbH). • Leonard W. T. Ng, Guohua Hu, Richard C. T. Howe, Xiaoxi Zhu, Zongyin Yang, Printing of Graphene and Related 2D Materials, in: Technology, Formulation and Applications. 1st ed., 2019, (Springer-Verlag GmbH) • Research papers presented in class 		
Examination		
Complex 3D Structures and Components from 2D Materials written exam, written exam / length of examination: 1 hours		

Module PHM-0048: Physics and Technology of Semiconductor Devices <i>Physics and Technology of Semiconductor Devices</i>		6 ECTS/LP
Version 1.0.0 (since WS09/10) Person responsible for module: apl. Prof. Dr. Helmut Karl		
Contents: 1. Basic properties of semiconductors (electronic bandstructure, doping, carrier excitations and carrier transport) 2. Semiconductor diodes and transistors 3. Semiconductor technology		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • Basic knowledge of solid-state and semiconductor physics such as electronic bandstructure, doping, carrier excitations, and carrier transport. • Application of developed concepts (effective mass, quasi-Fermi levels) to describe the basic properties of semiconductors. • Application of these concepts to describe and understand the operation principles of semiconductor devices such as diodes and transistors • Knowledge of the technologically relevant methods and tools in semiconductor micro- and nanofabrication. • Integrated acquisition of soft skills: autonomous working with specialist literature in English, acquisition of presentation techniques, capacity for teamwork, ability to document experimental results, and interdisciplinary thinking and working. 		
Workload: Total: 180 h 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study) 60 h lecture and exercise course (attendance)		
Conditions: recommended prerequisites: basic knowledge in solid state physics, statistical physics and quantum mechanics.		
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Physics and Technology of Semiconductor Devices Mode of Instruction: lecture Language: English Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- Yu und Cardona: Fundamentals of Semiconductors (Springer)
- Sze: Physics of Semiconductor Devices (Wiley)
- Sze: Semiconductor Devices (Wiley)
- Madelung: Halbleiterphysik (Springer)
- Singh: Electronic and Optoelectronic Properties of Semiconductor Structures (Cambridge University Press)

Part of the Module: [Physics and Technology of Semiconductor Devices \(Tutorial\)](#)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Contents:

see module description

Examination

Physics and Technology of Semiconductor Devices

written exam / length of examination: 90 minutes

Examination Prerequisites:

Physics and Technology of Semiconductor Devices

Module PHM-0049: Nanostructures / Nanophysics <i>Nanostructures / Nanophysics</i>		6 ECTS/LP
Version 1.2.0 (since WS09/10) Person responsible for module: Prof. Dr. István Kézsmárki		
Contents: <ol style="list-style-type: none"> 1. Semiconductor quantum wells, wires and dots, low dimensional electron systems 2. Magnetotransport in low-dimensional systems, Quantum-Hall-Effect, Quantized conductance 3. Optical properties of nanostructures and their application in modern optoelectronic devices, Nanophotonics 4. Fabrication and detection techniques of nanostructures 5. Ferroic properties of nanostructures (Ferroelectricity, Magnetism, Multiferroicity) 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students gain basic knowledge of the fundamental concepts in modern nanoscale science. • The students have detailed knowledge of low-dimensional semiconductor structures and how these systems can be applied for novel functional devices for high-frequency electronics and optoelectronics • The students gain competence in selecting different fabrication and characterization approaches for specific nanostructures. • The students are able apply these concepts to tackle present problems in nanophysics. • The students acquire scientific skills to search for scientific literature and to evaluate scientific content. 		
Workload: Total: 180 h 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study)		
Conditions: recommended prerequisites: basic knowledge in solid-state physics and quantum mechanics.		
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Nanostructures / Nanophysics Mode of Instruction: lecture Language: English Contact Hours: 4		
Learning Outcome: see module description		
Contents: see module description		
Literature: <ul style="list-style-type: none"> • Yu und Cardona: Fundamentals of Semiconductors • Singh: Electronic and Optoelectronic Properties of Semiconductor Structures (Cambridge University Press) • Davies: The Physics of low-dimensional Semiconductors (Cambridge University Press) 		

Examination

Nanostructures / Nanophysics

oral exam / length of examination: 30 minutes

Examination Prerequisites:

Nanostructures / Nanophysics

Module PHM-0052: Solid State Spectroscopy with Synchrotron Radiation and Neutrons <i>Solid State Spectroscopy with Synchrotron Radiation and Neutrons</i>		6 ECTS/LP
Version 1.2.0 (since WS09/10) Person responsible for module: Prof. Dr. Christine Kuntscher		
Contents: <ol style="list-style-type: none"> 1. Electromagnetic radiation: description, generation, detection [5] 2. Spectral analysis of electromagnetic radiation: monochromators, spectrometer, interferometer [2] 3. Excitations in the solid state: Dielectric function [2] 4. Infrared spectroscopy 5. Ellipsometry 6. Photoemission spectroscopy 7. X-ray absorption spectroscopy 8. Neutrons: Sources, detectors 9. Neutron scattering 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basics of spectroscopy and important instrumentation and methods, • have acquired the skills of formulating a mathematical-physical ansatz in spectroscopy and can apply these in the field of solid state spectroscopy, • have the competence to deal with current problems in solid state spectroscopy autonomously, and are able to judge proper measurement methods for application. • Integrated acquirement of soft skills. 		
Workload: Total: 180 h 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: basic knowledge in solid-state physics		
Frequency: annually	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Solid State Spectroscopy with Synchrotron Radiation and Neutrons Mode of Instruction: lecture Language: English Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- H. Kuzmany, Solid State Spectroscopy (Springer)
- N. W. Ashcroft, N. D. Mermin, Solid State Physics (Holt, Rinehart and Winston)
- J. M. Hollas, Modern Spectroscopy

Part of the Module: Solid State Spectroscopy with Synchrotron Radiation and Neutrons (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Solid State Spectroscopy with Synchrotron Radiation and Neutrons

oral exam / length of examination: 30 minutes

Examination Prerequisites:

Solid State Spectroscopy with Synchrotron Radiation and Neutrons

Module PHM-0056: Ion-Solid Interaction <i>Ion-Solid Interaction</i>		6 ECTS/LP
Version 1.0.0 (since WS09/10) Person responsible for module: apl. Prof. Dr. Helmut Karl		
Contents: <ul style="list-style-type: none"> • Introduction (areas of scientific and technological application, principles) • Fundamentals of atomic collision processes (scattering, cross-sections, energy loss models, potentials in binary collision models) • Ion-induced modification of solids (integrated circuit fabrication with emphasis on ion induced phenomena, ion implantation, radiation damage, ion milling and etching (RIE), sputtering, erosion, deposition) • Transport phenomena • Analysis with ion beams 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the physical principles and the basal mechanisms of the interaction between particles and solid state bodies in the energy range of eV to MeV, • are able to choose adequate physical models for specific technological and scientific applications, and • have the competence to work extensively autonomous on problems concerning the interaction between ions and solid state bodies. • Integrated acquirement of soft skills. 		
Workload: Total: 180 h 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study) 80 h studying of course content through exercises / case studies (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Basic Courses in Physics I–IV, Solid State Physics, Nuclear Physics		
Frequency: annually	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Ion-Solid Interaction Mode of Instruction: lecture Language: English Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- R. Smith, Atomic and ion collisions in solids and at surfaces (Cambridge University Press, 1997)
- E. Rimini, Ion implantation: Basics to device fabrication (Kluwer, 1995)
- W. Eckstein: Computer Simulation of Ion-Solid Interactions (Springer, 1991)
- H. Ryssel, I. Ruge: Ionenimplantation (Teubner, 1978)
- Y. H. Ohtsuki: Charged Beam Interaction with Solids (Taylor & Francis, 1983)
- J. F. Ziegler (Hrsg.): The Stopping and Range of Ions in Solids (Pergamon)
- R. Behrisch (Hrsg.): Sputtering by Particle Bombardment (Springer)
- M. Nastasi, J. K. Hirvonen, J. W. Mayer: Ion-Solid Interactions: Fundamentals and Applications (Cambridge University Press, 1996)
- <http://www.SRIM.org>

Part of the Module: Ion-Solid Interaction (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Ion-Solid Interaction

written exam / length of examination: 90 minutes

Examination Prerequisites:

Ion-Solid Interaction

Module PHM-0057: Physics of Thin Films <i>Physics of Thin Films</i>		6 ECTS/LP
Version 1.6.0 (since WS09/10) Person responsible for module: PD Dr. German Hammerl		
Contents: <ul style="list-style-type: none"> • Thin film growth: basics, thermodynamic considerations, surface kinetics, growth mechanisms • Thin film growth techniques: vacuum technology, physical vapor deposition, chemical vapor deposition • Analysis and characterization of thin films: in-sit methods, ex-situ methods, direct methods • Properties and applications of thin films 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know a broad spectrum of methods of thin film technology and material properties and applications of thin films, • have the competence to deal with current problems in the field of thin film technology largely autonomous, • are able to choose the right substrates and thin film materials for epitaxial thin film growth to achieve desired application conditions, • acquire skills of combining the various technologies for growing thin layers with respect to their properties and applications, and • acquire scientific soft skills to search for scientific literature, understand technical english, work with literature in the field of thin films, interpret experimental results. 		
Workload: Total: 180 h 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study)		
Conditions: none		
Frequency: each winter semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Physics of Thin Films Mode of Instruction: lecture Language: English Contact Hours: 4		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- H. Frey, G. Kienel, Dünnschichttechnologie (VDI Verlag, 1987)
- H. Lüth, Solid Surfaces, Interfaces and Thin Films (Springer Verlag, 2001)
- A. Wagendristel, Y. Wang, An Introduction to Physics and Technology of Thin Films (World Scientific Publishing, 1994)
- M. Ohring, The Materials Science of Thin Films (Academic Press, 1992)

Examination

Physics of Thin Films

written exam / length of examination: 90 minutes

Examination Prerequisites:

Physics of Thin Films

Module PHM-0058: Organic Semiconductors <i>Organic Semiconductors</i>		6 ECTS/LP
Version 1.3.0 (since WS09/10) Person responsible for module: Prof. Dr. Wolfgang Brütting		
Contents: Basic concepts and applications of organic semiconductors Introduction <ul style="list-style-type: none"> • Materials and preparation • Structural properties • Electronic structure • Optical and electrical properties Devices and Applications <ul style="list-style-type: none"> • Organic metals • Light-emitting diodes • Solar cells • Field-effect transistors 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic structural and electronic properties of organic semiconductors as well as the essential function of organic semiconductor devices, • have acquired skills for the classification of the materials taking into account their specific features in the functioning of components, • and have the competence to comprehend and attend to current problems in the field of organic electronics. • Integrated acquirement of soft skills: practicing technical English, working with English specialist literature, ability to interpret experimental results 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 40 h studying of course content through exercises / case studies (self-study) 40 h studying of course content using provided materials (self-study) 40 h studying of course content using literature (self-study)		
Conditions: It is strongly recommended to complete the module solid-state physics first. In addition, knowledge of molecular physics is desired.		
Frequency: annually	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Organic Semiconductors Mode of Instruction: lecture Language: English Contact Hours: 3		

Learning Outcome:

see module description

Contents:

see module description

Literature:

- M. Schwoerer, H. Ch. Wolf: Organic Molecular Solids (Wiley-VCH)
- W. Brütting: Physics of Organic Semiconductors (Wiley-VCH)
- A. Köhler, H. Bässler: Electronic Processes in Organic Semiconductors (Wiley-VCH)
- S.R. Forrest: Organic Electronics (Oxford Univ. Press)

Part of the Module: Organic Semiconductors (Tutorial)

Mode of Instruction: exercise course

Language: English

Frequency: every 3rd semester

Contact Hours: 1

Examination**Organic Semiconductors**

written exam / length of examination: 90 minutes

Examination Prerequisites:

Organic Semiconductors

Module PHM-0059: Magnetism <i>Magnetism</i>		6 ECTS/LP
Version 1.0.0 (since WS09/10) Person responsible for module: Dr. Hans-Albrecht Krug von Nidda		
Contents: <ul style="list-style-type: none"> • History, basics • Magnetic moments, classical and quantum phenomenology • Exchange interaction and mean-field theory • Magnetic anisotropy and magnetoelastic effects • Thermodynamics of magnetic systems and applications • Magnetic domains and domain walls • Magnetization processes and micro magnetic treatment • AC susceptibility and ESR • Spintransport / spintronics • Recent problems of magnetism 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic properties and phenomena of magnetic materials and the most important methods and concepts for their description, like mean-field theory, exchange interactions and micro magnetic models, • have the ability to classify different magnetic phenomena and to apply the corresponding models for their interpretation, and • have the competence independently to treat fundamental and typical topics and problems of magnetism. • Integrated acquirement of soft skills. 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study)		
Conditions: basics of solid-state physics and quantum mechanics		
Frequency: annually	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Magnetism		
Mode of Instruction: lecture		
Language: English		
Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- D. H. Martin, Magnetism in Solids (London Iliffe Books Ltd.)
- J. B. Goodenough, Magnetism and the Chemical Bond (Wiley)
- P. A. Cox, Transition Metal Oxides (Oxford University Press)
- C. Kittel, Solid State Physics (Wiley)
- D. C. Mattis, The Theory of Magnetism (Wiley)
- G. L. Squires, Thermal Neutron Scattering (Dover Publications Inc.)

Part of the Module: Magnetism (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Magnetism

written exam / length of examination: 90 minutes

Examination Prerequisites:

Magnetism

Module PHM-0060: Low Temperature Physics <i>Low Temperature Physics</i>		6 ECTS/LP
Version 1.1.0 (since WS09/10) Person responsible for module: Prof. Dr. Philipp Gegenwart		
Contents: <ul style="list-style-type: none"> • Introduction • Properties of matter at low temperatures • Cryoliquids and superfluidity • Cryogenic engineering • Thermometry • Quantum transport, criticality and entanglement in matter 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic properties of matter at low temperatures and the corresponding experimental techniques, • have acquired the theoretical knowledge to perform low-temperature measurements, • and know how to experimentally investigate current problems in low-temperature physics. 		
Workload: Total: 180 h 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 60 h lecture and exercise course (attendance) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: Physik IV - Solid-state physics		
Frequency: every 3rd semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Low Temperature Physics Mode of Instruction: lecture Language: English Contact Hours: 3		
Learning Outcome: see module description		

Contents:

- Introduction (temperature scale, history of low temperature physics)
- Properties of matter at low temperatures (specific heat, thermal expansion, electrical resistance, thermal conductivity)
- Cryoliquids and superfluidity (nitrogen, hydrogen, 4-He and 3-He: phase diagrams, superfluidity)
- Cryogenic engineering (liquefaction of gases, helium cryostats, dilution refrigerator, adiabatic demagnetization, further techniques)
- Thermometry (primary and secondary thermometers at different temperature regimes)
- Quantum Matter (quantum Transport, Quantum phase transitions, Quantum spin liquids)

Literature:

C. Enss, S. Hunklinger, Tieftemperaturphysik (Springer)
F. Pobell, Matter and Methods at Low Temperatures (Springer)

Part of the Module: Low Temperature Physics (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Low Temperature Physics

oral exam / length of examination: 30 minutes

Examination Prerequisites:

Low Temperature Physics

Module PHM-0066: Superconductivity <i>Superconductivity</i>		6 ECTS/LP
Version 1.0.0 (since WS11/12) Person responsible for module: Prof. Dr. Philipp Gegenwart		
Contents: <ul style="list-style-type: none"> • Introductory Remarks and Literature • History and Main Properties of the Superconducting State, an Overview • Phenomenological Thermodynamics and Electrodynamics of the SC • Ginzburg-Landau Theory • Microscopic Theories • Fundamental Experiments on the Nature of the Superconducting State • Josephson-Effects • High Temperature Superconductors • Application of Superconductivity 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • will get an introduction to superconductivity, • by a presentation of experimental results they will learn the fundamental properties of the superconducting state, • are informed about the most important technical applications of superconductivity. • Special attention will be drawn to the basic concepts of the main phenomeno-logical and microscopic theories of the superconducting state, to explain the experimental observations. • For self-studies a comprehensive list of further reading will be supplied. 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study)		
Conditions: <ul style="list-style-type: none"> • Physik IV – Solid-state physics • Theoretical physics I-III 		
Frequency: every 3rd semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Superconductivity Mode of Instruction: lecture Language: English Contact Hours: 4		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- W. Buckel, Supraleitung, 5. Auflage (VCH, Weinheim, 1994)
- W. Buckel und R. Kleiner, Supraleitung, 6. Auflage (WILEY-VCH, Weinheim, 2004)
- M. Tinkham, Introduction to Superconductivity, 2nd Edition (McGraw-Hill, Inc., New York, 1996, Reprint by Dover Publications Inc. Miniola , 2004)
- Weitere Literatur wird in der Vorlesung angegeben

Assigned Courses:

Superconductivity (lecture)

Examination

Superconductivity

oral exam / length of examination: 30 minutes

Examination Prerequisites:

Superconductivity

Module PHM-0068: Spintronics <i>Spintronics</i>		6 ECTS/LP
Version 1.6.0 (since SoSe14) Person responsible for module: PD Dr. German Hammerl		
Contents: <ul style="list-style-type: none"> • Basic micromagnetic interactions (exchange, anisotropy, DMI, stray fields, external fields) and where they come from • Emergence of spin textures such as domain walls and bubbles/skyrmions • Torques acting on the local magnetization (magnetic field torque, current in-plane spin-transfer torque, spin-Hall effect and spin-orbit torques) • Switching • Motion of spin textures, 1D model and Thiele equation • Magneto-resistance and Hall effects and their utility in electrical readout • Ultrafast effects • Device applications • Experimental techniques in the field of spintronics 		
Learning Outcomes / Competences: The students: The students: <ul style="list-style-type: none"> • know the fundamental interactions in magnetic materials, the basic spintronic effects, and the related device structures, • have the competence to deal with current problems in the field of spintronics largely autonomously, • are able to choose materials in order to achieve demanding properties in spintronic applications, • are able to design device components to achieve spin polarization, • acquire scientific skills in finding and understanding current literature dealing with spintronic devices and applications, identifying suitable materials and material combinations with respect to their applicability for spintronic devices. 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study)		
Conditions: none		
Frequency: each summer semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Spintronics Mode of Instruction: lecture Language: English Contact Hours: 3		

Learning Outcome:

see module description

Contents:

see module description

Literature:

- N. W. Ashcroft, N. D. Mermin, Solid State Physics, Cengage Learning (2011), ISBN: 81-315-0052-7
- C. Felser, G. H. Hechter, Spintronics - From Materials to Devices, Springer (2013), ISBN: 978-90-481-3831-9
- S. Bandyopadhyay, M. Cahay, Introduction to Spintronics, CRC Press (2008), ISBN: 978-0-9493-3133-6

Part of the Module: Spintronics (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Spintronics

written exam / length of examination: 90 minutes

Examination Prerequisites:

Spintronics

Module PHM-0069: Applied Magnetic Materials and Methods <i>Applied Magnetic Materials and Methods</i>		6 ECTS/LP
Version 1.1.0 (since WS14/15) Person responsible for module: Prof. Dr. Manfred Albrecht		
Contents: <ul style="list-style-type: none"> • Basics of magnetism • Ferrimagnets, permanent magnets • Magnetic nanoparticles • Superparamagnetism • Exchange bias effect • Magnetoresistance, sensors • Experimental methods (e.g. Mößbauer Spectroscopy, mu-SR) 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students know the basic terms and concepts of magnetism, • get a profound understanding of basic physical relations and their applications, • acquire the ability to describe qualitative observations, interpret quantitative measurements, and develop mathematical descriptions of physical effects of chosen magnetic material systems. • Integrated acquirement of soft skills: autonomous working with specialist literature in English, acquisition of presentation techniques, capacity for teamwork, ability to document experimental results, and interdisciplinary thinking and working. 		
Workload: Total: 180 h 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Basics in solid state physics		
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Applied Magnetic Materials and Methods		
Mode of Instruction: lecture		
Language: English		
Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		
Literature: Stephan Bundell, Magnetism in Condensed Matter, Oxford University Press, ISBN: 0-19-850591-4 (Pbk) J.M.C. Coey, Magnetism and Magnetic Materials, Cambridge University Press, ISBN: 978-0-521-81614-4 (hardback)		

Part of the Module: Applied Magnetic Materials and Methods (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Applied Magnetic Materials and Methods

oral exam / length of examination: 30 minutes

Examination Prerequisites:

Applied Magnetic Materials and Methods

Module PHM-0122: Non-Destructive Testing <i>Non-Destructive Testing</i>		6 ECTS/LP
Version 1.0.0 (since WS14/15) Person responsible for module: Prof. Dr. Markus Sause		
Contents: <ul style="list-style-type: none"> • Introduction to nondestructive testing methods • Visual inspection • Ultrasonic testing • Guided wave testing • Acoustic emission analysis • Thermography • Radiography • Eddy current testing • Specialized nondestructive methods 		
Learning Outcomes / Competences: The students <ul style="list-style-type: none"> • acquire knowledge in the field of nondestructive evaluation of materials, • are introduced to important concepts in nondestructive measurement techniques, • are able to independently acquire further knowledge of the scientific topic using various forms of information. • Integrated acquirement of soft skills 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: Basic knowledge on materials science, in particular composite materials		
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Non-Destructive Testing Mode of Instruction: lecture Language: English Contact Hours: 3		
Learning Outcome: see module description		
Contents: see module description		

Literature:

- Raj: Practical Non-destructive Testing
- Shull: Nondestructive Evaluation - Theory and Applications
- Krautkrämer: Ultrasonic testing of materials
- Grosse: Acoustic Emission Testing
- Rose: Ultrasonic waves in solid media
- Maldague: Nondestructive Evaluation of Materials by Infrared Thermography
- Herman: Fundamentals of Computerized Tomography

Further literature - actual scientific papers and reviews - will be announced at the beginning of the lecture.

Assigned Courses:

Non-Destructive Testing (lecture)

Part of the Module: Non-Destructive Testing (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Assigned Courses:

Non-Destructive Testing (Tutorial) (exercise course)

Examination

Non-Destructive Testing

written exam / length of examination: 90 minutes

Examination Prerequisites:

Non-Destructive Testing

Module PHM-0163: Fiber Reinforced Composites: Processing and Materials Properties <i>Fiber Reinforced Composites: Processing and Materials Properties</i>		6 ECTS/LP
Version 1.2.0 (since SoSe15) Person responsible for module: Dr. Judith Moosburger-Will		
Contents: <ul style="list-style-type: none"> • Production of fibers (e.g. glass, carbon, or ceramic fibers) • Physical and chemical properties of fibers and their precursor materials • Physical and chemical properties of commonly used polymeric and ceramic matrix materials • Semi-finished products • Composite production technologies • Application of fiber reinforced materials 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the physical and chemical properties of fibers, matrices, and fiber-reinforced materials. • know the basics of production technologies of fibers, polymeric, ceramic matrices, and fiber-reinforced materials. • know the application areas of composite materials. • have the competence to explain material properties of fibers, matrices, and composites. • have the competence to choose the right materials according to application relevant conditions. • are able to independently acquire further knowledge of the scientific topic using various forms of information. 		
Remarks: ELECTIVE COMPULSORY MODULE		
Workload: Total: 180 h 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Recommended: basic knowledge in materials science, basic lectures in organic chemistry		
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Fiber Reinforced Composites: Processing and Materials Properties Mode of Instruction: lecture Language: English Contact Hours: 3		

Literature:

- Morgan: Carbon fibers and their composites
- Ehrenstein: Polymeric materials
- Krenkel: Ceramic Matrix Composites
- Henning, Moeller: Handbuch Leichtbau
- Schürmann: Konstruieren mit Faser-Kunststoff-Verbunden
- Neitzel, Mitschang: Handbuch Verbundwerkstoffe

Further literature - actual scientific papers and reviews - will be announced at the beginning of the lecture.

Assigned Courses:

Fiber Reinforced Composites: Processing and Materials Properties (lecture)

Part of the Module: Fiber Reinforced Composites: Processing and Materials Properties (Tutorial)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Literature:

see lecture

Assigned Courses:

Fiber Reinforced Composites: Processing and Materials Properties (Tutorial) (exercise course)

Examination

Fiber Reinforced Composites: Processing and Materials Properties

written exam / length of examination: 90 minutes

Examination Prerequisites:

Fiber Reinforced Composites: Processing and Materials Properties

Module PHM-0168: Modern Metallic Materials <i>Modern Metallic Materials</i>		6 ECTS/LP
Version 1.0.0 (since SoSe15) Person responsible for module: Prof. Dr. Ferdinand Haider		
Contents: Introduction Review of physical metallurgy Steels: <ul style="list-style-type: none"> • principles • common alloying elements • martensitic transformations • dual phase steels • TRIP and TWIP steels • maraging steel • electrical steel • production and processing Aluminium alloys: <ul style="list-style-type: none"> • 2xxx • 6xxx • 7xxx • Processing – creep forming, hydroforming, spinforming Titanium alloys Magnesium alloys Superalloys Intermetallics, high entropy alloys		
Learning Outcomes / Competences: Students <ul style="list-style-type: none"> • learn about relevant classes of actual metallic alloys and their properties • acquire the skill to derive alloy properties from physical metallurgy principles and concepts • have the competence to choose and to explain appropriate metallic materials for special applications 		
Remarks: Scheduled every second summer semester.		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: Recommended: Knowledge of physical metallurgy and physical chemistry		
Frequency: each summer semester alternating with PHM-0167	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module

Part of the Module: Modern Metallic Materials

Mode of Instruction: lecture

Language: English

Contact Hours: 4

Literature:

Cahn-Haasen-Kramer: Materials Science and Technology

Original literature

Examination

Modern Metallic Materials

written exam / length of examination: 90 minutes

Examination Prerequisites:

Modern Metallic Materials

Module PHM-0193: Plasma Material Interaction <i>Plasma-Material-Wechselwirkung</i>		6 ECTS/LP
Version 2.2.0 (since WS17/18) Person responsible for module: apl. Prof. Dr.-Ing. Ursel Fantz		
Contents: <ul style="list-style-type: none"> Fundamentals of plasma material interactions (winter term) High heat load components in nuclear fusion devices (summer term) 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> Knowledge: The students know the fundamental plasma material interaction processes and their implication for nuclear fusion research in light of the technological boundary conditions and challenges. Skills: The students are proficient in a differentiated analysis of complex systems, based on learning from examples of power exhaust in fusion devices. Competencies: The students are competent in elaborating current topics of plasma material interaction. Integrated achievement of key qualifications: Acquirement of interdisciplinary knowledge, independent work with English literature, abstraction and approximation of complex processes using numerical models, application-oriented thinking and ability to contemplate about experimental results. 		
Remarks: The two lectures of this module can be followed in an arbitrary order. Thus, the module can be started at a summer or winter term.		
Workload: Total: 180 h 60 h studying of course content using provided materials (self-study) 60 h studying of course content using literature (self-study) 60 h lecture (attendance)		
Conditions: recommended: module "Plasmaphysik und Fusionsforschung"		Credit Requirements: general examination for entire module
Frequency: annually	Recommended Semester: from 2.	Minimal Duration of the Module: 2 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Fundamentals of plasma material interactions		
Mode of Instruction: lecture		
Language: English		
Frequency: each winter semester		
Contact Hours: 2		
Learning Outcome: see description of module		
Contents: Fundamental plasma boundary physics, erosion processes: physical sputtering, chemical erosion, radiation induced sublimation, arcs, experimental observation of surface processes in plasmas, methods for characterizing surfaces, coating techniques, hydrogen retention, surface modification by plasmas.		

<p>Literature:</p> <ul style="list-style-type: none"> • P. Stangeby: The plasma boundary of magnetic fusion devices (IOP, 2000) • R. Clark, D. Reiter (Eds.): Nuclear Fusion Research, Understanding Plasma-Surface Interactions (Springer, 2005) • O. Auciello, D. L. Flamm (Eds.): Plasma Diagnostics, Volume 2: Surface Analysis and Interactions (Plasma-Materials Interactions) (Academic Press, 1989) • M. Turnyanskiy et al.: European roadmap to the realization of fusion energy: Mission for solution on heat-exhaust systems (Fusion Engineering and Design, 2015)
<p>Assigned Courses:</p> <p>Fundamentals of plasma material interactions (lecture)</p>
<p>Part of the Module: High heat load components in nuclear fusion devices</p> <p>Mode of Instruction: lecture</p> <p>Language: English</p> <p>Frequency: each summer semester</p> <p>Contact Hours: 2</p>
<p>Learning Outcome:</p> <p>see description of module</p>
<p>Contents:</p> <p>Interdependency of material choices and fusion performance, material choices and technologies for power exhaust in a fusion power plant, migration of materials in a fusion plasma, diagnostics for plasma material interaction in fusion devices (in situ and post mortem), numerical methods for studying plasma material interaction.</p>
<p>Literature:</p> <ul style="list-style-type: none"> • P. Stangeby: The plasma boundary of magnetic fusion devices (IOP, 2000) • R. Clark, D. Reiter (Eds.): Nuclear Fusion Research, Understanding Plasma-Surface Interactions (Springer, 2005) • M. Turnyanskiy et al.: European roadmap to the realization of fusion energy: Mission for solution on heat-exhaust systems, Fusion Engineering and Design (2015) • V. A. Evtikhin et al.: Lithium divertor concept and results of supporting experiments, Plasma Phys. Control. Fusion 44, 955 (2002) • T. Hirai et al.: ITER tungsten divertor design development and qualification program, Fusion Eng. Des. 88, 1798 (2013) • A. R. Raffray et al.: High heat flux components - Readiness to proceed from near term fusion systems to power plants, Fusion Eng. Des. 85, 93 (2010)
<p>Examination</p> <p>Plasma Material Interaction</p> <p>oral exam / length of examination: 30 minutes</p>

Module PHM-0203: Physics of Cells <i>Physics of Cells</i>		6 ECTS/LP
Version 1.3.0 (since SoSe22) Person responsible for module: Dr. Christoph Westerhausen		
Contents: <ul style="list-style-type: none"> Physical principles in Biology Cell components and their material properties: cell membrane, organelles, cytoskeleton Thermodynamics of proteins and biological membranes Physical methods and techniques for studying cells Cell adhesion – interplay of specific, universal and elastic forces Tensile strength and elasticity of tissue - macromolecules of the extra cellular matrix Micro mechanics and properties of the cell as a biomaterial Cell adhesion Cell migration Cell actuation, cell-computer-communication, and cell stimulation 		
Learning Outcomes / Competences: The students <ul style="list-style-type: none"> know basic physical properties of human cells, as building blocks of living organisms and their material properties. know the basic functionality of mechanical and optical methods to study living cells know physical descriptions of fundamental biological processes and properties of biomaterials. are able to express biophysical questions and define model systems to answer these questions. The students improve the key competences: <ul style="list-style-type: none"> self-dependent working with English specialist literature. processing of experimental data. interdisciplinary thinking and working. 		
Workload: 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: Mechanics, Thermodynamics		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Physics of Cells		
Mode of Instruction: lecture		
Language: English / German		
Contact Hours: 2		
Learning Outcome: see module description		

Contents: see module description
Literature: <ul style="list-style-type: none">• Sackmann, Erich, and Rudolf Merkel. <i>Lehrbuch der Biophysik</i>. Wiley-VCH, 2010.• Heimburg, Thomas. <i>Thermal Biophysics of Membranes</i>. Wiley-VCH, 2007• Nelson, Philip. <i>Biological physics</i>. New York: WH Freeman, 2004.• Boal, D. <i>Mechanics of the Cell</i>. Cambridge University Press, 2012• Lecture notes
Assigned Courses: Physics of Cells (lecture)
Part of the Module: Physics of Cells (Tutorial) Mode of Instruction: exercise course Language: English Contact Hours: 2
Learning Outcome: see module description
Contents: see module description
Literature: see module description
Assigned Courses: Physics of Cells (Tutorial) (exercise course)
Examination Physics of Cells oral exam / length of examination: 30 minutes

Module PHM-0225: Analog Electronics for Physicists and Materials Scientists <i>Analog Electronics for Physicists and Materials Scientists</i>		6 ECTS/LP
Version 1.2.0 (since WS15/16) Person responsible for module: Andreas Hörner		
Contents: <ol style="list-style-type: none"> 1. Basics in electronic and electrical engineering 2. Quadrupole theory 3. Electronic Networks 4. Semiconductor Devices 5. Implementation of transistors 6. Operational amplifiers 7. Optoelectronic Devices 8. Measurement Devices 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic terms, concepts and phenomena of electronic and electrical engineering for the use in the Lab, • have skills in easy circuit design, measuring and control technology, analog electronics, • have expertise in independent working on circuit problems. They can calculate and develop easy circuits. 		
Workload: Total: 180 h 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study) 60 h lecture and exercise course (attendance)		
Conditions: none		
Frequency: each winter semester	Recommended Semester:	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Analog Electronics for Physicists and Materials Scientists Mode of Instruction: lecture + exercise Lecturers: Andreas Hörner Language: English Contact Hours: 4 ECTS Credits: 6.0		
Assigned Courses: Analog Electronics for Physicists and Materials Scientists (lecture + exercise)		
Examination Analog Electronics Analog Electronics for Physicists and Materials Scientists written exam / length of examination: 90 minutes Examination Prerequisites: Analog Electronics for Physicists and Materials Scientists		

Module PHM-0226: Digital Electronics for Physicists and Materials Scientists <i>Digital Electronics for Physicists and Materials Scientists</i>		6 ECTS/LP
Version 1.3.0 (since WS15/16) Person responsible for module: Andreas Hörner		
Contents: <ol style="list-style-type: none"> 1. Boolean algebra and logic gates 2. Digital electronics and calculation of digital circuits 3. Converters (Analog – Digital, Digital – Analog) 4. Principle of digital memory and communication, 5. Microprocessors and Networks 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the basic terms, concepts and phenomena of electronic and electrical engineering for the use in the Lab, • have skills in easy circuit design, measuring and control technology and digital electronics, • have expertise in independent working on circuit problems. They develop easy digital circuits and program microprocessors 		
Workload: Total: 180 h 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 60 h lecture and exercise course (attendance)		
Conditions: none		
Frequency: each summer semester	Recommended Semester:	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Digital Electronics for Physicists and Materials Scientists Mode of Instruction: lecture + exercise Lecturers: Andreas Hörner Language: English Contact Hours: 4 ECTS Credits: 6.0		
Examination Digital Electronics Digital Electronics for Physicists and Materials Scientists written exam / length of examination: 90 minutes		

Module PHM-0228: Symmetry concepts and their applications in solid state physics and materials science <i>Symmetry concepts and their applications in solid state physics and materials science</i>	6 ECTS/LP
Version 1.0.0 (since WS18/19) Person responsible for module: Prof. Dr. István Kézsmárki Deisenhofer, Joachim, Dr.	
<p>Contents:</p> <p>The topical outline of the course is as follows:</p> <ul style="list-style-type: none"> • Introduction and common examples <ul style="list-style-type: none"> o Motivating examples o Polar and axial vectors and tensors o Spatial and temporal symmetries and charge conjugation o Symmetries of measurable quantities and fields o Symmetries of physical laws (classical and quantum) o Conservation laws (linear and angular momentum, energy, etc.) o Symmetry of measurement configurations (reciprocity, etc.) • Neumann principle <ul style="list-style-type: none"> o Linear response theory and Onsager relations o Applications to vector and tensor quantities: electric and magnetic dipole moment of molecules; ferroelectricity, ferromagnetism, piezoelectricity and magnetoelectricity in crystals; wave propagation in anisotropic media (sound and light) • Symmetry allowed energy terms <ul style="list-style-type: none"> o On the level of classical free energy: Polar, nematic and magnetic order parameters (Landau expansion) o On the level of Hamiltonians: Molecular vibrations, crystal field potential, magnetic interactions • Symmetry of physical states <ul style="list-style-type: none"> o Spatial inversion and parity eigenstates o Discrete translations and the Bloch states • Spontaneous symmetry breaking upon phase transitions (Landau theory) • Outlook: Symmetry guides for skyrmion-host materials, multiferroic compounds and axion insulators 	
<p>Learning Outcomes / Competences:</p> <ul style="list-style-type: none"> • The students know the simple use of symmetry concepts to understand phenomena and material properties without performing detailed calculations. • The students know how to make minimal plans for experiments using the symmetry of the studied materials or vice versa how to determine the symmetry of materials from the output of experiments. • The students acquire scientific skills to search for scientific literature and to evaluate scientific content. 	
<p>Workload:</p> Total: 180 h 60 h (attendance) 60 h exam preparation (self-study) 60 h studying of course content (self-study)	

Conditions: Background in basic quantum mechanics is required.		
Frequency: nach Bedarf WS und SoSe	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module
<p>Part of the Module: Symmetry concepts and their applications in solid state physics and materials science</p> <p>Mode of Instruction: lecture</p> <p>Lecturers: Prof. Dr. István Kézsmárki</p> <p>Language: English</p> <p>Contact Hours: 3</p> <p>ECTS Credits: 6.0</p>
<p>Examination</p> <p>Symmetry concepts and their applications in solid state physics and materials science</p> <p>oral exam / length of examination: 30 minutes</p>

Parts of the Module
<p>Part of the Module: Symmetry concepts and their applications in solid state physics and materials science (Tutorial)</p> <p>Mode of Instruction: exercise course</p> <p>Language: English</p> <p>Contact Hours: 1</p>

Module PHM-0252: Optical Excitations in Materials <i>Optical Excitations in Materials</i>		6 ECTS/LP
Version 1.9.0 (since SoSe20) Person responsible for module: Prof. Dr. Joachim Deisenhofer		
Contents: 1. Classical Light-Matter Interaction in Solids: <ul style="list-style-type: none"> • Introduction: Typical Optical Response of Metals and Semiconductors • Classical electromagnetic wave propagation in linear optical media (Maxwell Equations, refractive index, reflection, transmission, absorption) • Anisotropic media, birefringence, longitudinal solutions • Classical Drude-Lorentz oscillator model • Spectroscopic techniques: Fourier-Transform-Spectroscopy, Time-domain Spectroscopy, Ellipsometry 2. Quantum Aspects of Light-Matter interaction <ul style="list-style-type: none"> • qm approach to absorption and emission: Lorentzian lineshape, Fermi's Golden Rule • Electric-dipole and magnetic-dipole approximation • Rabi-oscillations and the need for quantum optical approaches • A glimpse of non-linear optics 3. Excitations in different material classes <ul style="list-style-type: none"> • Optical properties of semiconductors/insulators, molecular materials, metals • Absorption and Luminescence, excitons, luminescence centers • Optoelectronics, detectors, light emitting devices • Quantum confined structures: tuning of absorption and emission 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • The students gain basic knowledge of the fundamental concepts of light-matter interaction in solids. • The students have detailed knowledge of classical models of light-propagation and absorption and get the competence to choose adequate spectroscopic techniques for measuring the optical properties of different material classes. • The students have a basic understanding of quantum aspects of optical processes in different materials. • The students are able apply these concepts to understand and analyse optical properties of different materials. • The students acquire scientific skills to search for scientific literature and to evaluate scientific content. 		
Workload: Total: 180 h 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using provided materials (self-study) 60 h lecture and exercise course (attendance)		
Conditions: Basic knowledge of classical electrodynamics, atomic and solid state physics.		
Frequency: each semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module

Part of the Module: Optical Excitations in Materials

Mode of Instruction: lecture

Language: English

Contact Hours: 4

ECTS Credits: 6.0

Literature:

1. Mark Fox, Optical Properties of Solids, Oxford Master Series
2. Mark Fox, Quantum Optics: An Introduction, Oxford Master Series
3. David B. Tanner, Optical Effects in Solids, Cambridge University Press
4. Y. Toyozawa, Optical Processes in Solids, Cambridge University Press

Assigned Courses:

Optical Excitations in Materials (lecture)

Examination

Optical Excitations in Materials

written exam / length of examination: 90 minutes

Module PHM-0253: Dielectric Materials <i>Dielectric Materials</i>		6 ECTS/LP
Version 1.2.0 (since SoSe20) Person responsible for module: PD Dr. Peter Lunkenheimer		
Contents: <ul style="list-style-type: none"> • Experimental techniques: quantities, broadband dielectric spectroscopy, nonlinear and polarization measurements • Dynamic processes in dielectric materials: relaxation processes, phenomenological models • Dielectric properties of disordered matter: liquids, glasses, plastic crystals • Charge transport: hopping conductivity, universal dielectric response • Ionic conductivity: conductivity mechanism, dielectric properties, advanced electrolytes for energy-storage devices • Maxwell-Wagner relaxations: equivalent-circuits, applications (supercapacitors), colossal-dielectric-constant materials • Electroceramics: Materials, Properties (relaxor ferroelectric, ferroelectric, antiferroelectric and multiferroic), Applications 		
Learning Outcomes / Competences: Students know the fundamentals of electromagnetic wave propagation and have a sound background for a broad spectrum of dielectric phenomena. They are able to analyze materials requirements and to interpret dielectric spectra in a broad frequency range. They have the competence to select materials for different kinds of applications and to critically assess experimental results on dielectric properties.		
Remarks: Elective compulsory module		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 20 h studying of course content using provided materials (self-study) 20 h studying of course content using literature (self-study) 80 h studying of course content through exercises / case studies (self-study)		
Conditions: Basic knowledge of solid state physics		
Frequency: each summer semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Dielectric Materials Mode of Instruction: lecture Lecturers: PD Dr. Stephan Krohns, PD Dr. Peter Lunkenheimer Language: English / German		

Literature:

- F. Kremer and A. Schönhal (eds.), Broadband Dielectric Spectroscopy (Springer, Berlin, 2002).
- F. Kremer and A. Loidl (eds.), The scaling of relaxation processes (Springer, Cham, 2018).
- A.K. Jonscher, Dielectric Relaxations in Solids (Chelsea Dielectrics Press, London, 1983).
- C.J.F. Böttcher and P. Bordewijk, Theory of electric polarisation Vol II (Elsevier, Amsterdam, 1973).
- S.R. Elliott, Physics of Amorphous Materials (Longman, London, 1990)
- A.J.Moulson, J.M. Herbert, Electroceramics: Materials, Properties, Applications (Wiley, 2003)
- R. Waser, U. Böttger, S. Tiedke, Polar Oxides: Properties, Characterization, and Imaging (Wiley, 2005)

Examination

Dielectric Materials Dielectric Materials

presentation / length of examination: 45 minutes

Examination Prerequisites:

Dielectric Materials

Module PHM-0268: Porous Functional Materials <i>Poröse funktionale Materialien</i>	6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Dirk Volkmer	
Contents: (i) Einleitung und historischer Überblick (ii) Theorie (1) Wichtige Klassen poröser Materialien: Strukturen und Herstellungsmethoden a) Zeolithe, MCM-Materialien und silikatische Aergele b) Poröse Kohlenstoffe u. Kohlenstoffnitride c) Metall-Organische Gerüstverbindungen (MOFs) d) Kovalente Organische Gerüstverbindungen e) Poröse Flüssigkeiten und Gläser f) Flexible und Stimulus-responsive poröse Materialien (2) Physisorption in porösen Materialien a) Instrumentelle Methoden zur Bestimmung von spezifischer Oberfläche und Porosität b) Auswertung von Physisorptionsisothermen c) Atomistische Modellierung von Diffusion und Stofftransport (3) Ausgewählte Methoden der Struktur- und Thermoanalytik zur Charakterisierung poröser Materialien a) Thermoanalytische Methoden b) Dynamische Chemisorptionsanalyse c) Multikomponenten-Gasadsorption, Durchbruchkurven und IAST (iii) Anwendungen (4) Speicherung chemischer Stoffe in porösen Materialien a) Speicherung von wichtigen Energieträgern (H ₂ /Methan) b) CO ₂ -Fixierung c) Pharmakologischer Wirkstofftransport u.-freisetzung (5) Stofftrennprozesse a) Poröse Materialien in industriellen Trennprozessen b) Membran-Trenntechnologie (6) Heterogene Katalyse a) Zeolithe in der industriellen Katalyse b) Photokatalyse u. künstl. Photosynthese (7) Integration poröser Materialien in integrierte Schaltkreise und Sensoren	
Learning Outcomes / Competences: <ul style="list-style-type: none"> • Die Studierenden wissen die Designprinzipien, Herstellungs- und Charakterisierungsmethoden poröser Materialien, • wissen wichtige technische Anwendungen poröser Materialien • besitzen die Fertigkeit zur atomistischen Modellierung von porösen Materialien und Sorptionsprozessen • besitzen die Fertigkeit zur mathematischen Auswertung von Sorptions-analytischen Daten zur Bestimmung der spezifischen Oberfläche und Porosität der Materialien • besitzen Kompetenzen in der selbstständigen Bearbeitung von Problemstellungen aus den genannten Themenbereichen 	
Remarks: Das Modul kann in den Studiengängen Master Materialchemie und Master Materials Science and Engineering belegt werden	
Workload: Total: 180 h 30 h studying of course content using provided materials (self-study)	

30 h studying of course content using literature (self-study) 60 h studying of course content through exercises / case studies (self-study) 45 h lecture (attendance) 15 h exercise course (attendance)		
Conditions: keine		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 3.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module**Part of the Module: Poröse funktionale Materialien****Mode of Instruction:** lecture**Language:** German**Contact Hours:** 3**Lehr-/Lernmethoden:**

Beamerpräsentation, Blended Learning

Part of the Module: Übung zu Poröse funktionale Materialien**Mode of Instruction:** exercise course**Language:** German**Contact Hours:** 1**Lehr-/Lernmethoden:**

Tutorium, Beamerpräsentationen, Tafelanschrieb

Literature:

- Pascal Van Der Voort, Karen Leus, Els De Canck, Introduction to Porous Materials (Wiley, 1. Ausgabe 2019), ISBN-13 # : # 978-1119426608

Examination**Poröse funktionale Materialien**

oral exam, Einzel oder Gruppenprüfung (Prüfungsdauer pro Person) / length of examination: 30 minutes

Module PHM-0269: Materials for electrochemical energy storage <i>Materialien zur elektrochemischen Energiespeicherung</i>		6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Leo van Wüllen		
Contents: <ul style="list-style-type: none"> • elektrochemische Grundlagen • elektrochemische Energiespeicher: Superkondensatoren und Batterien • Batteriesysteme • Li-Ionen-Batterien • Redox-flow-Batterien • Metall-Fluorid-Batterien • Neue Materialien für Anode, Kathode, Elektrolyt und Separator 		
Learning Outcomes / Competences: Die Studierenden <ul style="list-style-type: none"> • kennen die grundlegenden Konzepte zur elektrochemischen Energiespeicherung • erhalten spezifische Kenntnisse über die wichtigsten aktuellen Batterie- und Akkumulatorsysteme • erhalten die Fertigkeit, für spezifische Einsatzfelder die geeigneten Batteriesysteme zu identifizieren • erwerben die Kompetenz, Materialien hinsichtlich ihrer Eignung als Anoden-, Kathoden- und Elektrolytmaterialien auszuwählen und zu beurteilen • Integrierter Erwerb von Schlüsselqualifikationen: Fähigkeit sich in ein naturwissenschaftliches Spezialgebiet einzuarbeiten und das erworbene Wissen aktiv zur Lösung wissenschaftlicher Fragestellungen anzuwenden 		
Remarks: Das Modul kann auch im Studiengang Master Materials Science and Engineering belegt werden.		
Workload: Total: 180 h 15 h exercise course (attendance) 45 h lecture (attendance) 120 h studying of course content using provided materials (self-study)		
Conditions: none		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Materialien zur elektrochemischen Energiespeicherung Mode of Instruction: lecture Language: German Contact Hours: 3		
Learning Outcome: siehe Modulbeschreibung		
Contents: siehe Modulbeschreibung		

Literature:

Hamann, C. H., Vielstich, W. (2005). *Elektrochemie*. (4. Auflage) Wiley-VCH Verlag GmbH.
Job, R. (2020). *Electrochemical Energy Storage*. Walter de Gruyter GmbH.
Kurzweil, P. (2015). *Elektrochemische Speicher: Superkondensatoren, Batterien, Elektrolyse-Wasserstoff, Rechtliche Rahmenbedingungen*. Springer-Verlag Berlin Heidelberg.

Part of the Module: Übung zu Materialien zur elektrochemischen Energiespeicherung

Mode of Instruction: exercise course

Language: German

Contact Hours: 1

Learning Outcome:

siehe Modulbeschreibung

Examination

Materialien zur elektrochemischen Energiespeicherung

oral exam, Einzel- oder Gruppenprüfung; Prüfungsdauer pro Person: 30 Minuten

Module PHM-0271: Photonic Materials <i>Photonische Materialien</i>		6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Henning Höppe		
Contents: <ul style="list-style-type: none"> • Einführung in grundlegende Konzepte • Silicatanaloge Materialien und Halbleiter • Lumineszierende Materialien • Pigmente • Anwendungsbeispiele • Grundsätze guter wissenschaftlicher Praxis 		
Learning Outcomes / Competences: <ul style="list-style-type: none"> • Die Studierenden kennen die grundlegenden theoretischen Konzepte (wie Ligandenfeld- und Bändertheorie), die zur Beschreibung charakteristischer Bindungsverhältnisse in Festkörpern notwendig sind; sie sind vertraut mit den Ordnungsprinzipien in Festkörpern (Kristallographie und Gruppentheorie) und verfügen über Grundkenntnisse in Stoffchemie und Festkörpersynthesen • Die Studierenden können die optischen Eigenschaften photonischer Materialien erklären und analysieren. • Sie erwerben die Kompetenz, ausgehend von bekannten Materialien die Eigenschaften neuer Verbindungen abzuschätzen und einen sinnvollen synthetisch-strategischen Zugang zu diesen Verbindungen zu erarbeiten. • Integrierter Erwerb von Schlüsselqualifikationen: Fähigkeit sich in ein naturwissenschaftliches Spezialgebiet einzuarbeiten und das erworbene Wissen aktiv zur Lösung wissenschaftlicher Fragestellungen anzuwenden 		
Remarks: Das Modul kann in den Studiengängen Master Materialchemie und Master Materials Science and Engineering belegt werden.		
Workload: Total: 180 h 15 h exercise course (attendance) 45 h lecture (attendance) 20 h studying of course content using provided materials (self-study) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study)		
Conditions: none		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Photonische Materialien Mode of Instruction: lecture Language: German Contact Hours: 3		
Learning Outcome: siehe Modulbeschreibung		

Contents:

siehe Modulbeschreibung

Literature:

- W. Yen, S. Shionoya, H. Yamamoto, Phosphor Handbook, The CRC Press laser and optical science and technology series, CRC Press/Taylor and Francis, 2007.
- B. Henderson und G. Imbusch, Optical spectroscopy of inorganic solids, Monographs on the Physics and Chemistry of Materials, Oxford University Press, 2006.
- A. Fox, Optical Properties of Solids, Oxford master series in condensed matter physics, Oxford University Press, 2001.
- weitere wird in der Vorlesung bekanntgegeben

Assigned Courses:

Photonische Materialien (lecture + exercise)

Part of the Module: Übung zu Photonische Materialien

Mode of Instruction: exercise course

Language: German

Contact Hours: 1

Learning Outcome:

siehe Modulbeschreibung

Examination

Photonische Materialien

written exam / length of examination: 90 minutes

Module PHM-0274: Materials under extreme conditions <i>Materialien unter extremen Bedingungen</i>		6 ECTS/LP
Version 1.0.0 (since SoSe22) Person responsible for module: Prof. Dr. Wolfgang Scherer		
Contents: <ul style="list-style-type: none"> • Einführung in die Hochtemperatur- und Hochdruckchemie in Lösung und im Festkörper • Experimentelle Techniken zur Synthese und Charakterisierungen von Materialien unter extremen Bedingungen • Einfluss von Druck und Temperatur auf die Reaktionen anorganischer und organischer Verbindungen • Materialeigenschaften und physikalischen Eigenschaften von Festkörpern unter extremen Bedingungen • Anwendungen in der Hochdruckchemie und Design von Materialien 		
Learning Outcomes / Competences: Die Studierenden <ul style="list-style-type: none"> • erlangen Grundkenntnisse in der Synthese und <i>in-situ</i> Charakterisierung von Festkörpern und molekularen Materialien bei hohem Druck und hohen Temperaturen. • kennen die grundlegenden Konzepte, die zum Verständnis der komplexen Bindungsverhältnisse, Strukturchemie und physikalischer Eigenschaften von Materialien unter extremen Bedingungen unabdingbar sind: <ul style="list-style-type: none"> - Molekülorbitaltheorie - Bandstrukturanalyse - Ligandenfeldtheorie - spektroskopische Methoden - Beugungsmethoden • erlangen die Fähigkeit strukturelle und physikalische Phasenübergänge in Abhängigkeit von Druck und Temperatur zu analysieren und interpretieren. • können grundlegende Strategien anwenden, um die elektronische Struktur von Festkörpern und damit die Materialeigenschaften in Abhängigkeit externer Kontrollparameter (Druck, Temperatur) maßzuschneidern. Damit erwerben sie die Schlüsselqualifikation, sich in ein naturwissenschaftliches Spezialgebiet einzuarbeiten und das erworbene Wissen zur Lösung anwendungsorientierter Fragestellungen, wie dem Design von Materialien mit maßgeschneiderten physikalischen Eigenschaften, umzusetzen. 		
Remarks: Das Modul kann in den Studiengängen Master "Materialchemie" und Master "Materials Science and Engineering" belegt werden.		
Workload: Total: 180 h 45 h lecture (attendance) 15 h exercise course (attendance) 30 h studying of course content using literature (self-study) 60 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using provided materials (self-study)		
Conditions: none		Credit Requirements: Bestehen der Modulprüfung
Frequency: each winter semester	Recommended Semester: from 3.	Minimal Duration of the Module: 1 semester[s]

Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
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Parts of the Module**Part of the Module: Materialien unter extremen Bedingungen****Mode of Instruction:** lecture**Language:** German**Contact Hours:** 3**Learning Outcome:**

siehe Modulbeschreibung

Contents:

siehe Modulbeschreibung

Lehr-/Lernmethoden:

Vorlesung, Beamerpräsentation, Tafelanschrieb

Literature:

- R. van Eldik, F.-G. Klärner, *High Pressure Chemistry: Synthetic, Mechanistic, and Supercritical Applications*, WILEY-VCH, 1st Ed., 2002
- V.D. Blank, E.I. Estrin, *Phase Transitions in Solids Under High Pressure*, CRC Press, 1st Ed., 2014.
- J. Gilman, *Electronic Basis of the Strength of Materials*, Cambridge, 1st Ed., 2014.
- R. M. Hazen, R.T. Downs, *High-Temperature and High-Pressure Crystal Chemistry*, Mineralogical Society of America, 2000.
- U. Schubert, N. Hüsing, *Synthesis of Inorganic Materials*, Wiley-VCH, 3rd Edition, 2012.
- N. Wiberg, *Lehrbuch der Anorganischen Chemie*, Walter de Gruyter, ebook, 102. Auflage, 2007.

Part of the Module: Übungen zu Materialien unter extremen Bedingungen**Mode of Instruction:** exercise course**Language:** German**Contact Hours:** 1**Learning Outcome:**

siehe Modulbeschreibung

Examination**Materialien unter extremen Bedingungen**

written exam / length of examination: 90 minutes

Module INF-0277: Analyzing Massive Data Sets <i>Analyzing Massive Data Sets</i>		8 ECTS/LP
Version 1.2.0 (since SoSe18) Person responsible for module: Prof. Dr. Peter Michael Fischer		
<p>Learning Outcomes / Competences: After attending the course, students will be able to understand and evaluate the concepts and methods, procedures, techniques, and technologies for analyzing massively large data sets. Possible content includes:</p> <ul style="list-style-type: none"> • Fundamentals of information retrieval • Similarity search and clustering • Analysis of data streams and temporal data • Web graphs: Link analysis and social networks • Dynamic networks and information diffusion • Recommender systems and online advertising • Computational methods for massive data sets <p>Students will also be able to implement technical solution concepts for analyzing large data sets in programs. Key Skills: Ability to think logically, analytically and conceptually, weigh up approaches to solutions, acquire abstraction skills; subject-specific in-depth knowledge; implement subject-specific solution concepts in programs and models; knowledge of the advantages/disadvantages of design alternatives and evaluation in the respective application context; selection and confident application of suitable methods; ability to make scientifically meaningful evaluations using suitable methods; ability to solve problems under practical boundary conditions; competence in recognizing significant technical developments;</p>		
<p>Workload: Total: 240 h 30 h studying of course content using literature (self-study) 90 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using provided materials (self-study) 60 h lecture (attendance) 30 h exercise course (attendance)</p>		
<p>Conditions: Module Database Systems (INF-0073) - recommended Module Discrete structures for computer science (INF-0109) - recommended Module Computer Science 3 (INF-0111) - recommended</p>		
Frequency: irregular (usu. summer semester)	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
<p>Part of the Module: Analyzing Massive Data Sets (Vorlesung) Mode of Instruction: lecture Language: English Contact Hours: 4</p>		
<p>Contents: The lecture covers basic concepts for the analysis of massively large data sets such as information extraction, similarity search, clustering, link and network analysis as well as their implementation.</p>		

Literature:

- Mining of Massive Datasets. J. Leskovec, A. Rajaraman, J.D. Ullman. Cambridge University Press, 2014
- D. Easley, J. Kleinberg. Networks, Crowds, and Markets: Reasoning About a Highly Connected World. Cambridge University Press, 2010.
- R. Baeza-Yates, B. Ribeiro-Neto: Modern Information Retrieval

Weitere Literatur wird in der Vorlesung bekannt gegeben

Part of the Module: Analyzing Massive Data Sets (Übung)

Mode of Instruction: exercise course

Language: English / German

Contact Hours: 2

Examination

Analyzing Massive Data Sets

written exam / length of examination: 90 minutes

Module INF-0316: Machine Learning and Computer Vision <i>Machine Learning and Computer Vision</i>		8 ECTS/LP
Version 1.0.0 (since SoSe19) Person responsible for module: Prof. Dr. Rainer Lienhart		
<p>Learning Outcomes / Competences: After successful participation in this module, students possess advanced knowledge of machine learning (decision trees, neural networks and deep neural networks, hypothesis evaluation, instance-based learning, Bayesian learning, learning theory), data reduction (e.g. principal component analysis), advanced image processing and machine vision and are able to apply them. They can analyse, understand and programmatically implement scientifically complex procedures in the field of multimedia data processing, as well as to appropriately apply the principles learned to new problems. They develop skills in logical, analytical and conceptual thinking in the field of digital signal processing and multimedia data processing.</p> <p>Key qualifications: advanced mathematical-formal logic; implementation of subject-specific solution concepts; interdisciplinary knowledge; development and implementation of solution strategies for complex problems; systematic further development of design methods; ability to solve problems under practical boundary conditions.</p>		
<p>Workload: Total: 240 h 30 h exercise course (attendance) 60 h lecture (attendance) 30 h studying of course content using provided materials (self-study) 90 h studying of course content through exercises / case studies (self-study) 30 h studying of course content using literature (self-study)</p>		
Conditions: none		
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 6	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Machine Learning and Computer Vision (Lecture)		
Mode of Instruction: lecture		
Language: German		
Contact Hours: 4		
<p>Contents: The lecture gives a good overview of all aspects of machine learning and machine extraction of information from multimedia data (e.g. "Google Image Search", "Google Goggles"). The learned concepts will be practised, analysed, and evaluated in the exercises using successful examples from practice. At the end of the semester, advanced topics such as object detection and object recognition of faces and people will be covered. The contents of the lecture include: Machine Learning (Decision Tree Learning, Artificial Neural Networks, Bayesian Learning, Discrete Adaboost), Data Reduction (Quantization (K-Means Clustering, Affinity Propagation), Dimensionality Reduction Techniques (PCA, NMF, Random Projection, MDS)) and Image Processing & Computer Vision (Salient Feature Points and Feature Descriptors, Object Detection (Face/Car/People Detection), Object Recognition (Face Recognition), Image Search with pLSA).</p>		
<p>Literature: Literature references will be announced at the beginning of the semester.</p>		

Part of the Module: Machine Learning and Computer Vision (Tutorial)

Mode of Instruction: exercise course

Language: German

Contact Hours: 2

Examination

Machine Learning and Computer Vision (Exam)

written exam / length of examination: 120 minutes

Description:

The examination can be taken every semester during the examination period.

Module MRM-0112: Finite element modeling of multiphysics phenomena <i>Finite-Elemente-Modellierung von Multiphysik-Phänomenen</i>		6 ECTS/LP
Version 2.9.0 (since WS19/20) Person responsible for module: Prof. Dr. Markus Sause Dozenten: Prof. Dr. Sause / Prof. Dr Peter		
Learning Outcomes / Competences: The students <ul style="list-style-type: none"> • get to know existing numerical methods for modeling and simulation of physical processes and systems • Learn the use and application of numerical methods for realistic problems • Are able to apply basic functional principles of a FEM program by using "COMSOL Multiphysics". 		
Remarks: This module is offered by faculty from MRM and Mathematics. It is intended for physics, MSE and WING students, who want to get an insight into a modern FEM program as it is used in academic and industrial applications.		
Workload: Total: 180 h		
Conditions: Recommended: MTH-6110 - Numerische Verfahren für Materialwissenschaftler, Physiker und Wirtschaftsingenieure		Credit Requirements: Bestehen der Modulprüfung
Frequency: each summer semester	Recommended Semester: from 1.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	
Parts of the Module		
Part of the Module: Finite-Elemente-Modellierung von Multiphysik-Phänomenen		
Mode of Instruction: lecture Lecturers: Prof. Dr. Malte Peter, Prof. Dr. Markus Sause Language: German Contact Hours: 2		
Contents: The following content will be presented: <ul style="list-style-type: none"> • Modeling and simulation of physical processes and systems. • Basic concepts of FEM programs • Generation of meshes • Optimization strategies • Selection of solver algorithms • Example applications from electrodynamics • Example applications from thermodynamics • Example applications from continuum mechanics • Example applications from fluid dynamics • Coupling of differential equations for the solution of multiphysics phenomena 		
Lehr-/Lernmethoden: Slide presentation, classroom discussion		

Literature:

- Grossmann, C., Roos, H.-G., & Stynes, M. (2007). Numerical Treatment of Partial Differential Equations. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-540-71584-9>
- Eck, C., Garcke, H., & Knabner, P. (2017). Mathematische Modellierung. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-662-54335-1>
- Temam, R., & Miranville, A. (2005). Mathematical Modeling in Continuum Mechanics. Cambridge: Cambridge University Press.

Examination

Finite-Elemente-Modellierung von Multiphysik-Phänomenen

written/oral exam / length of examination: 60 minutes

Parts of the Module

Part of the Module: Übung zu Finite-Elemente-Modellierung von Multiphysik-Phänomenen

Mode of Instruction: exercise course

Language: German

Contact Hours: 2

Lehr-/Lernmethoden:

Independent reflection of topics to deepen the lecture content

Module PHM-0174: Theoretical Concepts and Simulation <i>Theoretical Concepts and Simulation</i>		6 ECTS/LP
Version 1.0.0 (since WS09/10) Person responsible for module: Prof. Dr. Liviu Chioncel		
Contents: <ol style="list-style-type: none"> 1. Introduction: operating systems, programming languages, data visualization tools 2. Basic numerical methods: interpolation, integration 3. Ordinary and Partial Differential Equations (e.g., diffusion equation, Schrödinger equation) 4. Molecular dynamics 5. Monte Carlo simulations 		
Learning Outcomes / Competences: The students: <ul style="list-style-type: none"> • know the principal concepts of thermodynamics and statistical physics as well as the numerical methods relevant in material science, • are able to solve simple problems numerically. They are able to write the codes and to present the results, • have the expertise to find the numerical method appropriate for the given problem and to judge the quality and validity of the numerical results, • Integrated acquirement of soft skills: independent handling of hard- and software while using English documentations, ability to investigate abstract circumstances with the help of a computer and present the results in written and oral form, capacity for teamwork. 		
Remarks: Links to software related to the course: <ul style="list-style-type: none"> • http://www.bloodshed.net/ • http://www.cplusplus.com/doc/tutorial/ • http://www.cygwin.com/ • http://xmd.sourceforge.net/download.html • http://www.rasmol.org/ • http://felt.sourceforge.net/ 		
Workload: Total: 180 h 60 h lecture and exercise course (attendance) 80 h studying of course content through exercises / case studies (self-study) 20 h studying of course content using literature (self-study) 20 h studying of course content using provided materials (self-study)		
Conditions: Recommended: basic knowledge of quantum mechanics, thermodynamics, and numerical methods as well as of a programming language		Credit Requirements: project work in small groups, including a written summary of the results (ca. 10-20 pages) as well as an oral presentation
Frequency: each summer semester	Recommended Semester: from 2.	Minimal Duration of the Module: 1 semester[s]
Contact Hours: 4	Repeat Exams Permitted: according to the examination regulations of the study program	

Parts of the Module

Part of the Module: Theoretical Concepts and Simulation

Mode of Instruction: lecture

Language: English

Contact Hours: 3

Literature:

- Tao Pang, An Introduction to Computational Physics (Cambridge University Press)
- J. M. Thijssen, Computational Physics (Cambridge University Press)
- Koonin, Meredith, Computational Physics (Addison-Weseley)
- D. C. Rapaport, The Art of Molecular Dynamics Simulation, (Cambridge University Press)
- W. H. Press et al, Numerical Recipes (Cambridge University Press)

Part of the Module: Theoretical Concepts and Simulation (Project)

Mode of Instruction: exercise course

Language: English

Contact Hours: 1

Examination

Theoretical Concepts and Simulation

seminar / length of examination: 30 minutes

Examination Prerequisites:

Theoretical Concepts and Simulation