Module Descriptions

Master of Science Advanced Materials

Absorption:Biomaterials

Examination Regulations in the Version of: 2017
### Elective Courses II

#### Elective Courses II - Biomaterials in Medicine

<table>
<thead>
<tr>
<th>Course</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biophysics of Hearing and Seeing</td>
<td>1</td>
</tr>
<tr>
<td>Biomaterials in Medicine II</td>
<td>3</td>
</tr>
<tr>
<td>Biosensors and Biochips</td>
<td>6</td>
</tr>
<tr>
<td>Biosensors</td>
<td>9</td>
</tr>
<tr>
<td>Cell Interaction with Biomaterials and Imaging Techniques</td>
<td>11</td>
</tr>
<tr>
<td>Cell Mechanics and Interactions with Biomaterials</td>
<td>13</td>
</tr>
<tr>
<td>Laser, Laser-Matter Interactions</td>
<td>15</td>
</tr>
<tr>
<td>Advanced Laboratory Biomaterials in Medicine</td>
<td>18</td>
</tr>
<tr>
<td>Polymers in Medicine</td>
<td>20</td>
</tr>
</tbody>
</table>

#### Elective Courses II - Chemistry

<table>
<thead>
<tr>
<th>Course</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characterization Techniques for Fuel Cells and Batteries</td>
<td>22</td>
</tr>
<tr>
<td>Colloid Chemistry</td>
<td>25</td>
</tr>
<tr>
<td>Functional Properties of Nanomaterials</td>
<td>27</td>
</tr>
<tr>
<td>Hydrogen as Energy Carrier</td>
<td>29</td>
</tr>
<tr>
<td>Lithium Ion Batteries</td>
<td>31</td>
</tr>
<tr>
<td>Advanced Laboratory Chemistry</td>
<td>33</td>
</tr>
<tr>
<td>Polymeric Materials</td>
<td>35</td>
</tr>
<tr>
<td>Simulation and Modeling</td>
<td>37</td>
</tr>
<tr>
<td>Surface - Interfaces - Heterogeneous Catalysis - Electrocatalysis</td>
<td>39</td>
</tr>
</tbody>
</table>

#### Elective Courses II - Soft Matter/Biophysics

<table>
<thead>
<tr>
<th>Course</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basics of Scanning Electron Microscopy</td>
<td>41</td>
</tr>
<tr>
<td>Biophysics of Hearing and Seeing</td>
<td>43</td>
</tr>
<tr>
<td>Biophysics I</td>
<td>45</td>
</tr>
<tr>
<td>Cellular Biophysics</td>
<td>47</td>
</tr>
<tr>
<td>Graduate Seminar Biophysics and Soft Matter</td>
<td>49</td>
</tr>
<tr>
<td>Advanced Laboratory Biophysics and Soft Matter</td>
<td>51</td>
</tr>
<tr>
<td>Laboratory Principles of Scanning Electron Microscopy</td>
<td>53</td>
</tr>
<tr>
<td>Laboratory Principles of Transmission Electron Microscopy</td>
<td>55</td>
</tr>
<tr>
<td>Polymeric Materials</td>
<td>57</td>
</tr>
<tr>
<td>Principles of Transmission Electron Microscopy und Seminar</td>
<td>59</td>
</tr>
<tr>
<td>Smart Materials</td>
<td>61</td>
</tr>
</tbody>
</table>

### Compulsory Modules

<table>
<thead>
<tr>
<th>Module</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Biology</td>
<td>63</td>
</tr>
<tr>
<td>Biology</td>
<td>65</td>
</tr>
<tr>
<td>Biomaterials in Medicine</td>
<td>67</td>
</tr>
<tr>
<td>Chemistry</td>
<td>70</td>
</tr>
<tr>
<td>Materials and Engineering Science</td>
<td>72</td>
</tr>
<tr>
<td>Materials Chemistry</td>
<td>75</td>
</tr>
</tbody>
</table>
Mathematics 77
Physics I 79
Scientific Method Training 82

Additive Key Qualifications

Additive Key Qualifications 84
Additive Key Qualifications 85
German Language 87

Master Thesis

Master’s Thesis 90
Biophysics of Hearing and Seeing
Modules referring to Elective Courses II - Biomaterials in Medicine

Code 8822874268
ECTS credits 4
Attendance time 3
Language of instruction English
Duration Semester
Cycle keine Angaben
Coordinator Dean of Physics Studies
Instructor(s) Prof. Heinrich Hoerber
Allocation of study programmes
Physik M.Sc., elective module, 1\textsuperscript{st} or 2\textsuperscript{nd} semester
Wirtschaftsphysik M.Sc., elective module, 1\textsuperscript{st} – 3\textsuperscript{rd} semester
Recommended prerequisites None

Learning objectives The course "Biophysics of Hearing and Seeing" will provide a basic understanding of these senses with respect to their anatomy and physiology. In comparison with recent technical developments of optical and acoustic sensor systems, the physical principles to characterize the performance of these senses will be introduced.

Syllabus
• Evolution of seeing
• New developments in imaging and image processing techniques
• Anatomy and Physiology of the Eye
• Comparison between natural and artificial systems
• Introduction to Acoustic
• Anatomy and Physiology of the Ear
• Comparison between natural and artificial systems

Literature
<table>
<thead>
<tr>
<th>Teaching and learning methods</th>
<th>Lecture with exercises, block course</th>
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<tbody>
<tr>
<td>Workload</td>
<td></td>
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<tr>
<td>60 hours lecture with exercises (attendance time)</td>
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<tr>
<td>60 hours self-study and exam preparation</td>
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<td>Total: 120 hours</td>
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<tr>
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<tr>
<td>Grading procedure</td>
<td>The grade of the module will be the grade of the exam.</td>
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<tr>
<td>Basis for</td>
<td>Research in the field of Biophysics</td>
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Biomaterials in Medicine II
Modules referring to Elective Courses II - Biomaterials in Medicine

**Code** 8822873963

**ECTS credits** 3

**Attendance time** 2

**Language of instruction** English

**Duration** 1 Semester

**Cycle** each Winter Semester

**Coordinator** Prof. Dr. R. Brenner, Faculty of Medicine

**Instructor(s)** Prof. Dr. R. Brenner, Faculty of Medicine,

**Allocation of study programmes** Third semester MSc Advanced Materials, focus Biomaterials

**Recommended prerequisites** Modules Biology and Cell Biology, Biomaterials I

**Learning objectives** Biomaterials II

Students should be able to

- describe the desired or undesired degradation of different biomaterials in a biological environment
- describe the interaction between biomaterials and human tissues into which they have been introduced or implanted
- discuss the process of successful integration, as well as problems that may lead to dysfunction of biomaterials employed to replace or support tissues or structures of the human body
- refer to the regulatory standards for approval of biomaterials

Commercial Production of Biomaterials

Students should be able to

- depict production, processing and employment of biocompatible materials and devices designed for implantation in the human body, using a product of one of the companies visited as an example

Laboratory Biomaterials

Students should be able to
• understand how research on biomaterials is organized in a specialized laboratory and carried out by experienced researchers

### Syllabus

Biomaterials II

1. Degradation of biomaterials (changes in chemical composition and biological and mechanical properties)
   - Corrosions of metals
   - Degradation of polymers

2. Host reactions to biomaterials (integration, inflammation and foreign body reactions)
   - Blood reactions to biomaterials
   - In vitro cell-biomaterials reactions
   - In vivo tissue reactions to biomaterials
   - Systemic effects of biomaterials

3. Testing of biomaterials used in medical devices prior to their employment in order to avoid risks for recipients
   - Properties tested: Mechanical strength, biological degradation
   - In vitro testing of biomaterials (decreasing necessity for animal experiments)
   - In vivo testing of biomaterials

### Literature

- Handouts

### Teaching and learning methods

Biomaterials II

3 credit points
Lecture series, 2 h/week

Commercial Production of Biomaterials (Excursion)

2 credit points
1 h/week

Laboratory Biomaterials

3 credit points

### Workload

Biomaterials II: Total 90 h

32 h presence
42 h preparation and post processing
16 h exam preparation

Commercial Production of Biomaterials:

24 h presence (4 excursions, half a day to a whole day)

Laboratory Biomaterials:
Lab sessions

<table>
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<tr>
<th><strong>Assessment</strong></th>
<th>The grade of the module will be the grade of the oral or written (depending on the number of participants) exam. No prerequisites are necessary for exam registration.</th>
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<tbody>
<tr>
<td><strong>Grading procedure</strong></td>
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<tr>
<td><strong>Basis for</strong></td>
<td>Master’s thesis, elective courses focus Biomaterials</td>
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# Biosensors and Biochips

Modules referring to Elective Courses II - Biomaterials in Medicine

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<td>Attendance time</td>
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<td>Language of instruction</td>
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<tr>
<td>Duration</td>
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</tr>
<tr>
<td>Cycle</td>
<td>each Winter Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Dr. Alberto Pasquarelli</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Dr. Alberto Pasquarelli</td>
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</table>

## Allocation of study programmes

- Advanced Materials. M.Sc., Advanced lecture
- Biophysics, M.Sc., Specialization Module
- Communications Technology:
  - M.Sc., track ME/CCS, In-depth Module
  - M.Sc., both tracks CE and CCS (FSPO2015), Supplementary Module
- Electrical Engineering, M.Sc., In-depth Module

## Recommended prerequisites

Basic knowledge of chemistry and biochemistry help to understand the biological part of biosensors.

## Learning objectives

The world-wide need for chemical detection and analysis rise steadily. Several reasons lead to this trend, for instance, the rapid increase in the prevalence of diabetes, the increasing need for environmental and health monitoring, new legislative standards for food and drug quality control or even the early detection of biological and chemical terror attacks. Thanks to higher sensitivity and specificity, short response times and reduction of overall costs, biosensors can be very competitive in addressing these needs when compared to traditional methods.

Students can describe basic principles, mechanisms of action and applications of biosensors in different scenarios. After taking this module, participants can analyze biosensors, break-down the elementary components and identify and illustrate every individual function in the information flow, from recognition to transduction and transmission. Students illustrate the clinical and industrial applications in different biosensor market sectors, e.g. commodities for everyday needs.
consumer needs or professional equipments for research. Furthermore, they are able to understand and critically analyze research in biosensors. Finally, students are able to develop appropriate concepts and independently propose solutions for given problems.

**Syllabus**

- Introduction to biosensors
- Applications overview
- Biological detection methods: catalytic, immunologic, etc.
- Physical transduction methods: electrochemical, optical, gravimetric, etc.
- Immobilization techniques: adsorption, entrapment, cross-linking, covalent bonds
- Biochip technologies: DNA and protein chips, ion-channel devices, MEA and MTA, Implants
- Laboratory practice with assigned projects carried-out in small groups with final report and demonstration in the class
- Extras: Student seminars, invited talk(s), excursion

**Literature**

- Lecture Notes

Further suggested books for deeper inside view:
- Handbook of Biosensors and Biochips, ISBN 9780470019054
- Gillez: Biomolecular sensors, ISBN 074840791X
- Jay: Modern Food Microbiology, ISBN: 9780387234137

**Teaching and learning methods**

Lecture “Biosensors and Biochips”, 4 SWS
Student seminar, 0,25 SWS
Laboratory project, 20 h

Excursion complete day (Not compulsory)

**Workload**

Active Time: 80 h
Preparation and Evaluation: 120 h
Self-Study: 40 h
Sum: 240 h

**Assessment**

The grade of the module will be the grade of the written exam. Prerequisite for exam registration is passing the pre-course (to be defined by the examiner).

**Grading procedure**

The grade of the module will be the grade of the exam.

**Basis for**

Masters Thesis in the area of biosensors.
Biosensors
Modules referring to Elective Courses II - Biomaterials in Medicine

<table>
<thead>
<tr>
<th>Code</th>
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</tr>
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<td>Attendance time</td>
<td>2</td>
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<tr>
<td>Language of instruction</td>
<td>English</td>
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<tr>
<td>Duration</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Cycle</td>
<td>each Semester</td>
</tr>
</tbody>
</table>
| Coordinator   | Prof. Dr.-Ing. Hermann Schumacher  
Dr. Alberto Pasquarelli |
| Instructor(s) | Dr. Alberto Pasquarelli |
| Allocation of study programmes | Electrical Engineering, M.Sc., Elective Module  
Electrical Engineering, M.Sc., Optional Module, General Electrical Engineering  
Electrical Engineering, M.Sc., Optional Module, Communication and System Technology  
Electrical Engineering, M.Sc., Optional Module, Automation and Energy Technology  
Electrical Engineering, M.Sc., Optional Module, Microelectronics  
Communications Technology, M.Sc., Elective Module, Microelectronics |
| Recommended prerequisites | Basic knowledge of chemistry and biochemistry help understanding the biological part of biosensors. |
| Learning objectives | The world-wide need for chemical detection and analysis rise steadily. Several reasons lead to this trend, for instance the rapid increase in the prevalence of diabetes, the increasing need for environmental and health monitoring, new legislative standards for food and drug quality control or even the early detection of biological and chemical terror attacks. Thanks to higher sensitivity and specificity, short response times and reduction of overall costs, biosensors can be very competitive in addressing these needs when compared to traditional methods.  
Students can describe basic principles, mechanisms of action and applications of biosensors in different scenarios. After taking this module, participants can analyze biosensors, break-down the elementary components and identify and illustrate every individual function in the information flow, from recognition to transduction and transmission. Students illustrate the clinical and industrial applications in different biosensor market sectors, e.g. commodities for everyday consumer needs or professional equipments for research. Furthermore, they are able to understand and critically analyze research in biosensors. Finally, students |

Master of Science Advanced Materials  
Date printed: 18. Juli 2018  
page 9 of 91
are able to develop appropriate concepts and independently propose solutions for given problems.

**Syllabus**

- Introduction to biosensors
- Applications overview
- Biological detection methods: catalitic, immunologic, etc
- Physical transduction methods: electrochemical, optical, gravimetric, etc.
- Immobilization techniques: adsorption, entrapment, cross-linking, covalent bonds
- Biochip technologies: DNA and protein chips, Ion-channel devices, MEA and MTA
- Extras: invited talk(s), experimental exercise, excursion

**Literature**

For in-depth study, following books are recommended:
- Springer e-Books (full pdf download at https://ulm.ibs-bw.de):
  - Jay: Modern Food Microbiology, ISBN: 9780387234137

**Teaching and learning methods**

Lecture “Biosensors”, lecture with demonstrations and seminars, 1,75 SWS
Seminar “Biosensors”, 0,25 SWS
Labor “Biosensors”, 2 x 2 h

**Workload**

Active Time: 28 h
Preparation and Evaluation: 50 h
Self-Study: 12 h
Sum: 90 h

**Assessment**

The grade of the module will be the grade of the written exam. No prerequisites are necessary for exam registration

**Grading procedure**

The grade of the module will be the grade of the exam.

**Basis for**

Masters Thesis in the area of biosensors.
Cell Interaction with Biomaterials and Imaging Techniques
Modules referring to Elective Courses II - Biomaterials in Medicine

Code 8822870945

ECTS credits 2

Attendance time 1

Language of instruction English

Duration 1 Semester

Cycle each Summer Semester

Coordinator Dr. Ralf Kemkemer

Instructor(s) Dr. Ralf Kemkemer

Allocation of study programmes Master degree in Advanced Materials, elective, 2. semester

Recommended prerequisites Introductory Biology and Cell Biology

Learning objectives Students are able to:
- understand and explain basic features and physical models of cell adhesion and interaction with physically and chemically micro- and nano-structured materials

Syllabus Special emphasis is on recent developments in that rapidly growing field:
I. Introduction to the cell and cytoskeleton and adhesion elements
II. Interaction of cells with topographical features of surfaces and response to physical and chemical structures of materials
III. Design and application of nanostructured materials for cellular biotechnology
IV. Imaging techniques for cell studies (fusion proteins, FRET)

Literature Roland Glaser, Biophysics, Springer
handouts
<table>
<thead>
<tr>
<th><strong>Teaching and learning methods</strong></th>
<th>Cell Interaction with Biomaterials and Imaging Techniques (L) 1 h/week</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Workload</strong></td>
<td>14 h lecture (presence)</td>
</tr>
<tr>
<td></td>
<td>30 h preparation and revision lecture</td>
</tr>
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<td></td>
<td>16 h exam preparation</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
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</tr>
<tr>
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</tr>
<tr>
<td><strong>Basis for</strong></td>
<td>MSc Advanced Materials, Biomaterials</td>
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</tbody>
</table>
Cell Mechanics and Interactions with Biomaterials
Modules referring to Elective Courses II - Biomaterials in Medicine

Code 8822870624
ECTS credits 2
Attendance time 1
Language of instruction English
Duration 1 Semester
Cycle each Winter Semester
Coordinator Dr. Ralf Kemkemer
Instructor(s) Dr. Ralf Kemkemer

Allocation of study programmes Master degree in Advanced Materials, elective, 3. semester

Recommended prerequisites Introductory Biology and Cell Biology, General Chemistry

Learning objectives Cells are very adaptive systems and respond to various external signals. Besides chemical stimuli, cells react to mechanical manipulations as well as physical properties of the materials they interact with. Studies of the mechanics of single cells, subcellular components and biological molecules have rapidly evolved during the past decade with significant implications for biotechnology, tissue engineering, and human health. This lecture introduces some basic features of the deformation of single cells and the interaction of cells with physically and chemically micro- and nano-structured materials. Special emphasis is on recent developments in that rapidly growing field.

Syllabus
1. Introduction to the cell and cytoskeleton elements
2. Basic mechanical properties of filaments and networks
3. Experiments for mechanical probing and manipulation of single cells,
   - measuring the elastic properties of cells
   - mechanical manipulation of cells
   - how does it sense mechanical forces
   - what force can a cell apply during cell movement
4. Interaction of cells with topographical features of surfaces, sensing and response to physical and chemical structures of materials
5. Design and application of nanostructured materials for cellular biotechnology

**Literature**
Roland Glaser, Biophysics, Springer
handouts

**Teaching and learning methods**
Cell Interaction with Biomaterials and Imaging Techniques (L) 1 h/week

**Workload**
14 h lecture (presence)
30 h preparation and postprocessing lecture
16 h exam preparation

**Total: 60 h**

**Assessment**
The grade of the module will be the grade of the oral or written (depending on the number of participants) exam. No prerequisites are necessary for exam registration.

**Grading procedure**
The grade of the module will be the grade of the exam.

**Basis for**
MSc course of studies Advanced Materials
# Laser, Laser-Matter Interactions

Modules referring to Elective Courses II - Biomaterials in Medicine

<table>
<thead>
<tr>
<th>Code</th>
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<tbody>
<tr>
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<tr>
<td>Duration</td>
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<tr>
<td>Cycle</td>
<td>irregular</td>
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<tr>
<td>Coordinator</td>
<td>Dr. Alwin Kienle</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>PD Dr. Alwin Kienle; Institute of Lasertechnology in Medicine and Metrology</td>
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</tbody>
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**Allocation of study programmes**
- Advanced Materials MSc, Studienbeginn WiSe, elective, 3rd semester
- Physics M.Sc., elective module, 1st or 2nd Semester
- Elektrotechnik - Mikroelektronik MSc, elective module

**Recommended prerequisites**
- Physics I, Materials Science I

**Learning objectives**
- to understand the physics and techniques of lasers
- to gain a broad overlook concerning the variety of lasers and possible applications
- to understand the various interaction mechanisms of laser radiation with materials
- to be prepared to use lasers in practice
- to be able to select appropriate lasers and laser parameters for a given task
- to train presentation skills: lecture, presentation (powerpoint) material, script

**Syllabus**
The course consists of:
- lectures (16 h)
- short seminar presentations (textbook level) (4h)
- extended presentations (scientific level) (8 h)
- exercises (class discussions of homework) (2h)
- demonstrations (2h)

Syllabus:
- physical background of generation of laser radiation
- setup of lasers
- characterization of laser radiation
- transport and focusing of laser radiation
- physical and technical properties of laser types
- theoretical description of light,
- optical properties of dielectrics, semi-conductors, metals
- modelling of reflection, absorption, scattering, and light distribution: Fresnel, Lorentz, Rayleigh, Mie, Boltzman transport Monte Carlo
- time scales of excitation and relaxation
- photochemical effects
- heating and heat transport, heat confinement
- melting, surface vaporisation
- special laser induced phase changes: confined boiling, phase explosions
- plasma formation
- mechanical side effects, pressure confinement, shock waves, spallation
- modelling of laser ablation
- dependence of effects on laser parameters
- laser applications in material processing
- laser applications in material production
- laser applications physics, biology, and medicine

**Literature**

Handouts:
- printout of lecture material
- book chapter copies

Reference texts:

a) General

b) Laser physics
- dtv-Atlas zur Atomphysik, dtv, 1980
c) Optical properties of matter and light propagation
- Bergmann, Schaefer.: Lehrbuch der Experimentalphysik, Band 3, Optik, de Gruyter, 1993
- Bergmann, Schaefer.: Lehrbuch der Experimentalphysik, Band 6, Festksrper, de Gruyter, 1992
- C.F. Bohren, D.R. Huffmann.: Absorption and Scattering of Light by Small Particles, Wiley, 1983
- Handbook of Chemistry and Physics, CRC, 1986
d) Laser material interactions

**Teaching and learning methods**

Laser, Laser/Material-Interaction, and Applications (L), 1 h/week, elective, 3. semester
Laser, Laser/Material-Interaction, and Applications (S), 1 h/week, elective, 3. semester

**Workload**

14 h lecture (presence)
14 h exercises, practical training (presence)
18 h preparation and revision lecture
28 h solution of exercises, revision
16 h exam preparation
Total: 90 h

Assessment
No english version available yet.

Grading procedure
No english version available yet.

Basis for
# Advanced Laboratory Biomaterials in Medicine

**Modules referring to Elective Courses II - Biomaterials in Medicine**

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<tr>
<td><strong>Duration</strong></td>
<td>1 Semester</td>
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<tr>
<td><strong>Cycle</strong></td>
<td>each Semester</td>
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<tr>
<td><strong>Coordinator</strong></td>
<td>Prof. Dr. K.-E. Gottschalk</td>
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<tr>
<td><strong>Instructor(s)</strong></td>
<td>Lecturers of Biomaterials specialisation and related institutes</td>
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<tr>
<td><strong>Allocation of study programmes</strong></td>
<td>Master Advanced Materials, elective module, semester 2 or 3</td>
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| **Recommended prerequisites** | Formal prerequisites (according to Study order and examination regulations): none  
Prerequisites regarding to the contents: Bachelor's competences in the field related to the subject |
| **Learning objectives** | The students who have finished this module successfully,  
- earn the skill and competence to work independently on a project in theory and practice in a selected field of biomaterials research, write it down, discuss it academically in a short treatise, and present it clearly. |
| **Syllabus**    | In this module the following contents are given: Practical research project on a topical subject in selected areas of biomaterials research from the working groups |
| **Literature**  | - it is made available  
- independent literature search |
| **Teaching and learning methods** | Project work (lab course) Biomaterials with written elaboration and presentation in the working group or institute |
| **Workload**          | Attendance: 180 h  
|                      | preparation & report: 60 h  
|                      | Total: 240 h  
| **Assessment**       | The award of the credit points for this module is based on completion of an assignment (presentation and paper), active participation in discussions and practical skills. No prerequisites are necessary for exam registration  
| **Grading procedure**| The grade of the module will be the grade of the exam.  
| **Basis for**        | Research in this field  

# Polymers in Medicine

Modules referring to Elective Courses II - Biomaterials in Medicine

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<td>Language of instruction</td>
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</tr>
<tr>
<td>Duration</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Cycle</td>
<td>each Winter Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Dr. Stefan Beck</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Dr. Stefan Beck</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
<td>Master Advanced Materials, elective module, 3. semester</td>
</tr>
<tr>
<td>Recommended prerequisites</td>
<td>-</td>
</tr>
</tbody>
</table>

### Learning objectives

The course will give an idea about daily challenges in industrial R&D on polymeric biomaterials. Biomaterials are substances other than food or drugs contained in therapeutic or diagnostic systems that are in contact with tissue or biological fluids. Biomaterials play a central role in extra corporeal devices, from contact lenses to kidney dialyses, and are essential components of implants, from vascular grafts to cardiac pacemakers and fracture fixation devices. The development and availability of modern high tech polymers allowed for the improvement of patients' care in all fields of medicine.

### Syllabus

In this course, we will (1) gain an overview of the use of polymeric biomaterials in medicine, (2) discuss some examples of permanent and resorbable polymer implants in more detail, (3) take a look at legal and regulatory aspects, (4) learn about functional and design requirements when dealing with polymers in medicine, and (5) will look into some future concepts.

### Literature

will be announced by the lecturer
<table>
<thead>
<tr>
<th><strong>Teaching and learning methods</strong></th>
<th>lecture (1 h/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Workload</strong></td>
<td>30 h lecture (attendance time)</td>
</tr>
<tr>
<td></td>
<td>30 h preparation</td>
</tr>
<tr>
<td></td>
<td>Total: 60 h</td>
</tr>
<tr>
<td><strong>Assessment</strong></td>
<td>The grade of the module will be the grade of the oral or written (depending on the number of participants) exam. No prerequisites are necessary for exam registration.</td>
</tr>
<tr>
<td><strong>Grading procedure</strong></td>
<td>The grade of the module will be the grade of the exam.</td>
</tr>
<tr>
<td><strong>Basis for</strong></td>
<td>Basis for research in field of Polymers and biomaterials</td>
</tr>
</tbody>
</table>
# Characterization Techniques for Fuel Cells and Batteries

**Modules referring to Elective Courses II - Chemistry**

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<tr>
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<td>Language of instruction</td>
<td>English</td>
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<tr>
<td>Duration</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Cycle</td>
<td>each Winter Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Head of the ZSW respective Head of the HIU</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Dr. Roswitha Zeis</td>
</tr>
</tbody>
</table>

## Allocation of study programmes
- Master Chemistry, Study Program Chemistry, elective or specialization (Energy Technology), 1.-3. Semester
- Master Chemistry and Management, specialization / Module Group 2 (Energy Technology), 1.-3. semester
- Master Energy Science and Technology, elective, 1.-3. semester
- Master Advanced Materials, elective, 1.-3. semester

## Recommended prerequisites
- **Formal prerequisites (according to Study order and examination regulations):** none
- **Prerequisites regarding to the contents:** Bachelor’s competences in the field related to the subject

## Learning objectives
- Student should be able to
  - # describe and explain diagnostics employed in the characterization and determination of Proton Exchange Membrane (PEM) fuel cells and battery performance.
  - # gain a more precise understanding of the physical and chemical processes that occur in PEM fuel cells and batteries based on knowledge of these diagnostic tools.
  - # start working on a master thesis in the field of electrochemical energy converters and storage devices.
This module provides the following content:

1. In situ cell tests
   # Steady state voltage-current measurements
   # Polarisation and charge-discharge curves
   # Impedance spectroscopy
   # Neutron scattering
   # Synchrotron radiation

2. Evaluation of cell components (Membranes, Separators, Electrolytes, Electrodes, Catalysts, Gas Diffusion Layers ...)
   # Structural analysis (SEM, TEM, XRD, microtomography, porosity determination)
   # Elemental analysis (XRF, ICP-MS, EDX)
   # Electrochemical surface area (BET, cyclic volammetry)
   # Catalytic activity (Rotating Ring Disk Electrode)
   # Membrane degradation (Neutron scattering, Fenton test)

**Literature**
- Handouts

**Teaching and learning methods**
Lecture (2 hours per week, 3 CP)

**Workload**
Presence: 30 h
Self Study: 60 h
Total: 90 h

**Assessment**
The grade of the module will be the grade of the oral or written (depending on the number of participants) exam. No prerequisites are necessary for exam registration

**Grading procedure**
The grade of the module will be the grade of the exam.

**Basis for**
Research in field of Fuel cells and Batteries
Colloid Chemistry
Modules referring to Elective Courses II - Chemistry

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<td>Duration</td>
<td>1 Semester</td>
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<tr>
<td>Cycle</td>
<td>each Summer Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Prof. Dr. Ulrich Ziener</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Dr. Ulrich Ziener</td>
</tr>
</tbody>
</table>

**Allocation of study programmes**
- Master Chemistry, Study Program Chemistry, elective or specialization (Macromolecular Chemistry), 1.-3. semester
- Master Chemistry, Study Program Materials, elective, 1.-3. semester
- Master Chemistry and Management, specialization / Module Group 2 (Macromolecular Chemistry), 1.-3. semester
- Master Advanced Materials, elective, 1.-3. semester

**Recommended prerequisites**
- Formal prerequisites (according to Study order and examination regulations): none
- **Prerequisites regarding to the contents:** Bachelor’s competences in the field related to the subject

**Learning objectives**
- Students who have successfully completed this module
- know the essential details of the synthesis and characterization of (polymeric) colloids

**Syllabus**
- This module provides the following content:
  - history of colloid chemistry
  - stabilization of colloids
  - surface-active agents
  - applications of surface-active agents
<table>
<thead>
<tr>
<th>Literature</th>
<th>- Dörfler: Grenzflächen- und Kolloidchemie, Wiley-VCH</th>
</tr>
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<tbody>
<tr>
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<tr>
<td>Workload</td>
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<td></td>
<td>Private study: 60 h</td>
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<td></td>
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<td></td>
<td>or written (depending on the number of participants)</td>
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<td></td>
<td>exam. No prerequisites are necessary for exam</td>
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<tr>
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<td>registration</td>
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<td>Grading procedure</td>
<td>The grade of the module will be the grade of the</td>
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<tr>
<td></td>
<td>exam.</td>
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<td>Basis for</td>
<td>Research in the field of chemistry, polymers and</td>
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<td>Colloids</td>
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Functional Properties of Nanomaterials
Modules referring to Elective Courses II - Chemistry

Code 8822870919

ECTS credits 3

Attendance time 2

Language of instruction English

Duration 1 Semester

Cycle each Winter Semester

Coordinator PD Dr. Joachim Bansmann

Instructor(s) PD Dr. Joachim Bansmann

Allocation of study programmes
- Master Chemistry, Study Program Materials, elective, 1.-3 semester
- Master Advanced Materials, elective, 1.-3. semester

Recommended prerequisites

Formal prerequisites (according to Study order and examination regulations): none

Prerequisites regarding to the contents: Bachelor's competences in the field related to the subject

Learning objectives
The students who have finished this module successfully have knowledge and understanding
- about topical technologies for the production and characterisation of different Nanostructures
- of the physical properties of Nanostructures, based on their spatial construction structure (electronic, optical and magnetic qualities)

Syllabus
In this module the following contents are given:
- Introduction to the Nanoscience under consideration of the state of the technology
- Analytic possibilities in the Nanoscience: STM/STS, AEM, SEM, TEM
- Production and qualities of Nanostructures: "Top-Down" methods and new materials; "Bottom-Up" methods
- Electronic and optical qualities
- Magnetic qualities

<table>
<thead>
<tr>
<th><strong>Literature</strong></th>
<th>Handouts; are made available in the lecture</th>
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<tr>
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<td>Lecture (2 hours per week, 3 CP)</td>
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<tr>
<td><strong>Workload</strong></td>
<td>Presence study: 30 H</td>
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<tr>
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<td>Selfstudy: 60 H</td>
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<td>Sum: 90 H</td>
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<td><strong>Assessment</strong></td>
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<td><strong>Grading procedure</strong></td>
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<td><strong>Basis for</strong></td>
<td>Research in Nanomaterials</td>
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</table>
Hydrogen as Energy Carrier
Modules referring to Elective Courses II - Chemistry

Code 8822871326

ECTS credits 3

Attendance time 2

Language of instruction English

Duration 1 Semester

Cycle each Summer Semester

Coordinator PD Dr. Christian Mohrdieck

Instructor(s) PD Dr. Christian Mohrdieck

Allocation of study programmes
- Master Chemistry, Study Programm Chemistry, elective or specialization (Energy Technology), 1.-3. semester
- Master Chemistry and Management, specialization / Module Group 2 (Energy Technology), 1.-3. semester
- Master Energy Science and Technology, elective, 1.-3. semester
- Master Advanced Materials, elective, 1.-3. semester

Recommended prerequisites
Formal prerequisites (according to Study order and examination regulations): none

Prerequisites regarding to the contents: Bachelor’s competences in the field related to the subject

Learning objectives
Students who have successfully completed this module
- are familiar with the scientific, technical and economic aspects of hydrogen as a promising and environmentally friendly energy source
- have an idea of technical applications

Syllabus
This module provides the following content:
- Overview hydrogen in research and applications
- Production methods, logistics and infrastructure for hydrogen
- Hydrogen storage methods (non-compressed gaseous)
- Storage methods (compressed hydrogen gas)
- Hydrogen (re)fueling technology
- Process, stationary and alternative applications
- Application of hydrogen in transportation, fuel cell vehicles
- Hydrogen - Fuel Cell - Efficiency - Entropy
- Visit of hydrogen and fuel cell laboratory, witnessing a leakage test
- Visit of a hydrogen refueling station and fuel cell vehicle test drive
- Different pathways of hydrogen production and use. Comparison with other energy sources based on the complete energy chain efficiency and emissions
- Tool for the visualization of energy chain efficiency results
- Safety, regulations, codes and standards
- Future perspectives of hydrogen as an energy carrier

**Literature**

- Zuttel, Andreas; Borgschulte, Andreas; Schlapbach, Louis (eds.): Hydrogen as a future energy carrier (Wiley-VCH, Weinheim, 1. Auflage 2008)
- International seminar proceedings, 3rd (Springer Netherlands, 2003)

**Teaching and learning methods**

Lecture (2 hours per week)

**Workload**

Presence: 30 h  
Private study: 60 h  
Total: 90 h

**Assessment**

The grade of the module will be the grade of the oral or written (depending on the number of participants) exam. No prerequisites are necessary for exam registration

**Grading procedure**

The grade of the module will be the grade of the exam.

**Basis for**

Research in field of Energy and Energy conversion
## Lithium Ion Batteries

Modules referring to Elective Courses II - Chemistry

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<tr>
<th>Code</th>
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<td>Language of instruction</td>
<td>English</td>
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<tr>
<td>Duration</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Cycle</td>
<td>each Winter Semester</td>
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<tr>
<td>Coordinator</td>
<td>Head of the ZSW or Head of the HIU</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Dr. Margret Wohlfahrt-Mehrens</td>
</tr>
</tbody>
</table>

### Allocation of study programmes

- Master Chemistry, Study Programm Chemistry, elective or specialization (Energy Technology), 1.-3. semester
- Master Chemistry and Management, specialization / Module Group 2 (Energy Technology), 1.-3. semester
- Master Energy Science and Technology, elective, 1.-3. semester
- Master Advanced Materials, elective, 1.-3. semester

### Recommended prerequisites

- **Formal prerequisites (according to Study order and examination regulations):** none
- **Prerequisites regarding to the contents:** Bachelor's competences in the field related to the subject

### Learning objectives

- Students who have successfully completed this module,
  - are familiar with the basics of lithium-ion batteries
  - know the correlations between binary and ternary phase diagrams and electrochemistry
  - have distinctive knowledge of structure and property relationships in compounds

### Syllabus

- This module provides the following content:
  - Electrochemical energy storage systems
  - Introduction to Lithium batteries
  - Basic principles I
  - Cathode materials I
- Cathode materials II
- Nanomaterials
- Measurement techniques
- Anode materials I
- Anode materials II
- Electrolytes
- Electrode/Electrolyte interface (SEI)
- Battery management I
- Battery management II
- Alternative Systems, Lab visit ZSW

**Literature**

- M. Whittingham, Intercalation compounds, in fast ion transport, Dordrecht (1993)

**Teaching and learning methods**

Lecture (2 hours per week)

**Workload**

Presence: 30 h  
Private study: 60 h  
Total: 90 h

**Assessment**

The grade of the module will be the grade of the oral or written (depending on the number of participants) exam. No prerequisites are necessary for exam registration

**Grading procedure**

The grade of the module will be the grade of the exam.

**Basis for**

research in the field of Batteries
# Advanced Laboratory Chemistry

**Modules referring to Elective Courses II - Chemistry**

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<td>Duration</td>
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<td>Cycle</td>
<td>each Semester</td>
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<tr>
<td>Coordinator</td>
<td>Prof. Dr. K.E. Gottschalk</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Lecturers of the chemistry</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
<td>Master Advanced Materials, elective module, semester 2 or 3</td>
</tr>
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</table>

**Recommended prerequisites**

- **Formal prerequisites (according to Study order and examination regulations):** none
- **Prerequisites regarding to the contents:** Bachelor's competences in the field related to the subject

**Learning objectives**

The students who have finished this module successfully,

- earn the skill and competence to work independently on a project in theory and practice in a selected field of chemistry, write it down, discuss it academically in a short treatise, and present it clearly.

**Syllabus**

In this module the following contents are given:

Practical research project on a topical subject in selected areas of chemistry from the working groups

**Literature**

- it is made available
- independent literature search
<table>
<thead>
<tr>
<th><strong>Teaching and learning methods</strong></th>
<th>Project work (lab course) Chemistry with written elaboration and presentation in the working group or institute</th>
</tr>
</thead>
</table>
| **Workload**                     | Attendance: 180 h  
preperation & report: 60 h  
Total: 240 h |
| **Assessment**                   | The award of the credit points for this module is based on completion of an assignment (presentation and paper), active participation in discussions and practical skills. No prerequisites are necessary for exam registration. |
| **Grading procedure**            | The grade of the module will be the grade of the exam |
| **Basis for**                    | Research in selected field |
Polymeric Materials
Modules referring to Elective Courses II - Chemistry

Code 8822871305

ECTS credits 3

Attendance time 2

Language of instruction English

Duration 1 Semester

Cycle each Winter Semester

Coordinator Prof. Dr. Ulrich Ziener

Instructor(s) Prof. Dr. Ulrich Ziener

Allocation of study programmes
Master Chemistry, Study Program Chemistr, compulsory module (Macromolecular Chemistry), 1.-3. semester
Master Chemistry, Study Program Materials, compulsory module, 1.-3. semester
Master Chemistry and Management, specialization / Module Group 2 (Macromolecular Chemistry), 1.-3. semester
Master Advanced Materials, elective, 1.-3. semester

Recommended prerequisites Formal prerequisites (according to Study order and examination regulations): none

Prerequisites regarding to the contents: Bachelor’s competences in the field related to the subject

Learning objectives Students who have successfully completed this module,
- are able to understand and describe modern applications of organic and macromolecular materials

Syllabus This module provides the following content:
- Block copolymers for the synthesis of nanoparticles
- Conductive polymers
- Liquid crystalline polymers
- Nanostructuring
- Porous polymeric materials
- Thermoreversible gels
<table>
<thead>
<tr>
<th><strong>Literature</strong></th>
<th>Scientific articles in professional journals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teaching and learning methods</strong></td>
<td>Lecture (2 hours per week)</td>
</tr>
</tbody>
</table>
| **Workload** | Presence: 30 h  
Private study: 60 h  
Total: 90 h |
| **Assessment** | The grade of the module will be the grade of the oral or written (depending on the number of participants) exam. No prerequisites are necessary for exam registration |
| **Grading procedure** | The grade of the module will be the grade of the exam. |
| **Basis for** | If Macromolecular Chemistry is chosen as the "Fourth Subject", it is obligatory to pass Polymeric Materials (to complete the respective module group). |
Simulation and Modeling
Modules referring to Elective Courses II - Chemistry

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<tr>
<td>Cycle</td>
<td>each academic Year</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Prof. Dr. A. Latz, Faculty of Natural Sciences, Helmholtz Institute Ulm</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Dr. A. Latz, Faculty of Natural Sciences, Helmholtz Institute Ulm</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
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<tr>
<td>Recommended prerequisites</td>
<td></td>
</tr>
<tr>
<td>Learning objectives</td>
<td>Student will be able to</td>
</tr>
</tbody>
</table>
| Syllabus | • Transport theory  
|           | • Thermodynamics and chemical kinetics of electrochemical systems  
|           | • Introduction to simulation techniques  
|           | • Discretization of transport equations and kinetic equations  
|           | • Fundamentals of systems theory  
|           | • Modelling of Batteries  
|           | • Modelling of fuel cells  
|           | • Software exercises |
### Literature


### Teaching and learning methods

<table>
<thead>
<tr>
<th>Teaching and learning methods</th>
<th>Lecture, 2 h/week</th>
<th>Solving problems, 2 h/week</th>
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### Workload

<table>
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<td>Lecture</td>
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<td></td>
<td>50 h revision</td>
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<tr>
<td>Solving problems</td>
<td>32 h presence</td>
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<td>36 h preparation and revision</td>
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### Assessment

The credit points will be awarded once the written exam has been passed. No prerequisites are necessary for exam registration.

### Grading procedure

The grade of the module will be the grade of the exam.

### Basis for

Master thesis
**Surface - Interfaces - Heterogeneous Catalysis - Electro catalysis**

Modules referring to Elective Courses II - Chemistry

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<tr>
<td>Duration</td>
<td>1 Semester Semester</td>
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<tr>
<td>Cycle</td>
<td>each Summer Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Prof. Dr. R. J. Behm, Faculty of Natural Sciences</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Dr. R. J. Behm, Faculty of Natural Sciences</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
<td>Second semester MSc Energy Science and Technology and MSc Advanced Materials</td>
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<tr>
<td>Recommended prerequisits</td>
<td>Module Chemistry I</td>
</tr>
<tr>
<td>Learning objectives</td>
<td>Students should be able to</td>
</tr>
<tr>
<td></td>
<td>• describe basic aspects of solid surfaces and their properties (structure, electronic properties) as well as their interaction with adsorbates;</td>
</tr>
<tr>
<td></td>
<td>• describe basic principles of heterogeneous catalysis and catalytic reactions, and apply them to model reactions (CO oxidation and ammonia synthesis);</td>
</tr>
<tr>
<td></td>
<td>• explain fundamental principles of electrochemistry, including solid electrolyte interface, potentials, electrode kinetics, transport effects, basic electrochemical measurements;</td>
</tr>
<tr>
<td></td>
<td>• describe basic principles, energetics and kinetics of electrocatalytic reactions, focusing on fuel cell relevant reactions, and predict simple trends for suitable catalysts</td>
</tr>
</tbody>
</table>

| Syllabus | Surfaces: Phenomenologic thermodynamics of surfaces, surface structure and electronic properties of solid surfaces, interaction of molecules with surfaces (thermodynamics, kinetics and energetics); |
|          | Catalytic Surface Reaction (Heterogeneous Catalysis): Fundamental aspects, methodical approach, basic reaction types, activity, selectivity, electronic and structural effects, Sabatier principle, Brønstedt-Evans-Polanyi principle, model reactions (CO oxidation, ammonia synthesis); |
• Electrochemistry: Galvanic cells, potentials in electrochemistry, standard electrode potential, electrochemical double layer, electrode kinetics, transport effects, experimental methods;
• Electrocatalysis: General aspects, influence of the electric potential on energetics and kinetics of electrocatalytic reactions, kinetic / transport limitations in electrocatalytic reactions, internal resistance effects, examples of electrocatalytic reactions, temperature effects.

**Literature**


**Teaching and learning methods**

- 5 credit points
- Lecture 3h/week
- Seminar 1h/week

**Workload**

- Total 150 h
- 56 h lecture and seminar (presence)
- 78 h preparation and revision of lecture and seminar and solving of problems
- 16 h preparation for exam

**Assessment**

- The credit points will be awarded once the oral exam has been passed. No prerequisites are necessary for exam registration.

**Grading procedure**

- The grade of the module will be the grade of the exam.

**Basis for**

- Module *Energy Science and Technology III-Electrochemical EST*
- Research in field of *Energy and storage materials*
- Elective Course *Polymeric Materials*
## Basics of Scanning Electron Microscopy

Modules referring to Elective Courses II - Soft Matter/Biophysics

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</tr>
<tr>
<td>Cycle</td>
<td>each Summer Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Dean of Physics Studies</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Ute Kaiser</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
<td>Master Advanced Materials, elective module, 2nd Semester</td>
</tr>
<tr>
<td>Recommended prerequisites</td>
<td>None</td>
</tr>
</tbody>
</table>
| Learning objectives | Students who have successfully completed this module, 
  • are able to describe the function of basic components of a scanning electron microscope, 
  • are able to understand basic SEM modes: imaging, diffraction and spectroscopy. |

### Syllabus

In this module, the following topics will be covered:

• Components of the SEM
• Physical phenomena of electron-matter interaction

### Literature

Will be announced in lecture.
<table>
<thead>
<tr>
<th><strong>Teaching and learning methods</strong></th>
<th>Lecture (2 hours per week)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Workload</strong></td>
<td>30 hours lecture (attendance time)</td>
</tr>
<tr>
<td></td>
<td>30 hours self-study and exam preparation</td>
</tr>
<tr>
<td></td>
<td>Total: 60 hours</td>
</tr>
<tr>
<td><strong>Assessment</strong></td>
<td>The grade of the module will be the grade of the oral or written (depending on the number of participants) exam. No prerequisites are necessary for exam registration.</td>
</tr>
<tr>
<td><strong>Grading procedure</strong></td>
<td>The grade of the module will be the grade of the exam.</td>
</tr>
<tr>
<td><strong>Basis for</strong></td>
<td>Research in the field of Electron Microscopy</td>
</tr>
</tbody>
</table>
Biophysics of Hearing and Seeing
Modules referring to Elective Courses II - Soft Matter/Biophysics

Code 8822874268

ECTS credits 4

Attendance time 3

Language of instruction English

Duration Semester

Cycle keine Angaben

Coordinator Dean of Physics Studies

Instructor(s) Prof. Heinrich Hoerber

Allocation of study programmes Physics M.Sc., elective module, 1st or 2nd semester
Wirtschaftsphysik M.Sc., elective module, 1st – 3rd semester

Recommended prerequisites None

Learning objectives The course "Biophysics of Hearing and Seeing" will provide a basic understanding of these senses with respect to their anatomy and physiology. In comparison with recent technical developments of optical and acoustic sensor systems, the physical principles to characterize the performance of these senses will be introduced.

Syllabus
• Evolution of seeing
• New developments in imaging and image processing techniques
• Anatomy and Physiology of the Eye
• Comparison between natural and artificial systems
• Introduction to Acoustic
• Anatomy and Physiology of the Ear
• Comparison between natural and artificial systems

Literature
- The Evolution of the Eye, 8.10.2015, Georg Glaeser und Hannes F. Paulus, Springer

| Teaching and learning methods | Lecture with exercises, block course |
| Workload | 60 hours lecture with exercises (attendance time) |
| | 60 hours self-study and exam preparation |
| | Total: 120 hours |
| Assessment | The grade of the module will be the grade of the oral exam. No prerequisites are necessary for exam registration. |
| Grading procedure | The grade of the module will be the grade of the exam. |
| Basis for | Research in the field of Biophysics |
# Biophysics I

Modules referring to Elective Courses II - Soft Matter/Biophysics

<table>
<thead>
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<th>Code</th>
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<tr>
<td>ECTS credits</td>
<td>6</td>
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<td>Attendance time</td>
<td>7</td>
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<tr>
<td>Language of instruction</td>
<td>English</td>
</tr>
<tr>
<td>Duration</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Cycle</td>
<td>each Winter Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Prof. Jens Michaelis</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Christof Gebhardt, Prof. Jens Michaelis</td>
</tr>
</tbody>
</table>

### Allocation of study programmes
- Physics M.Sc., elective module, 1\(^{st}\) or 2\(^{nd}\) semester
- Wirtschaftsphysik M.Sc., elective module, 1\(^{st}\) – 3\(^{rd}\) Semester

### Recommended prerequisites
None

### Learning objectives
Students who successfully pass this module
- understand the basic concepts, ideas and methods of Biophysics
- are able to describe biophysical phenomena with simple physical models

### Syllabus
- Time and length scales in Biophysics
- Brownian motion and diffusion, chemotaxis of bacteria
- Physics at low Reynold's numbers
- Structure and mechanics of cellular biomolecules, methods of structure determination
- Polymer models for the description of biomolecules
- Protein folding
- Force spectroscopy
- Fluorescence spectroscopy and microscopy
- Electrostatics in Biophysics
- Neurobiology

### Literature
- Phillips, Kondev, Theriot: Physical Biology of the Cell, Garland Science
- Howard: Mechanics of Motor Proteins and the Cytoskeleton, Sinauer
- Berg: Random Walks in Biology, Princeton University Press
- Lakowicz: Principles of Fluorescence Spectroscopy, Springer
- Alberts: Molecular Biology of the Cell, Garland Science

| Teaching and learning methods | For students, who have already passed the Bachelor module “Soft Matter Physics and Biophysics”:
|                              |   • Fundamental Methods of Biophysics (Lecture, 2 hours/week) with exercise (1 hour/week), 2nd semester half
|                              |   • Biophysics Lab I (2 hours/week)

For students, who did not pass the Bachelor module “Soft Matter Physics and Biophysics”:

- Fundamental Methods of Biophysics for Physicists (lecture, 2 hours/week), 1st semester half
- Fundamental Methods of Biophysics (lecture, 2 hours/week) with exercises (1 hour/week), 2nd semester half

| Workload | For students, who have already passed the Bachelor module “Soft Matter Physics and Biophysics”:
|          | 30 hours lecture (attendance time)
|          | 15 hours exercises (attendance time)
|          | 30 hours lab
|          | 105 hours self-study and exam preparation
|          | Total: 180 hours

For students, who did not pass the Bachelor module “Soft Matter Physics and Biophysics”:

- 60 hours lecture (attendance time)
- 15 hours exercises (attendance time)
- 105 hours self-study and exam preparation
- Total: 180 hours

| Assessment | The credit points will be awarded once the written or the oral exam has been passed (depending on the number of participants). The type of examination will be announced in time - at least 4 weeks prior to the date of the exam. Prerequisites are necessary for exam registration.

| Grading procedure | The grade of the module will be the grade of the exam.

| Basis for | Modules Biophysics: Gene Expression, Biophysics: Molecular Motors and Biophysics: Cellular Biophysics |
Cellular Biophysics
Modules referring to Elective Courses II - Soft Matter/Biophysics

Code 8822874005
ECTS credits 3
Attendance time 2
Language of instruction English
Duration 1 Semester
Cycle each Summer Semester
Coordinator Prof. Jens Michaelis
Instructor(s) Prof. Kay Gottschalk

Allocation of study programmes
Physics M.Sc., elective module, 1st or 2nd semester
Biophysics M.Sc., elective module, 2nd semester
Wirtschaftsphysik M.Sc., elective module, 1st – 3rd semester

Recommended prerequisites
Principles of Biophysics

Learning objectives
The cell is the smallest living unit in the body. It fulfills a variety of specialized functions and interacts with the environment. Classically, biochemical interactions with the environment by soluble factors like hormones are considered. However, physical parameters like stiffness or shape also play an important role. The goal of the lecture is to highlight these physical triggers of cell function.

Syllabus
• The cell as a composite material: structure and function of the cytoskeleton
• Influence of Cell Shape on Cell Function
• mechanosignalling: Influence of substrate rigidity on cell function and mechanics
• Measurement of Cell mechanics: atomic force microscopy and microrheology
• Measurements of Cellular Forces: Traction Force Microscopy

Literature
• Phillips, Kondev, Theriot: Physical Biology of the Cell, Garland 2013
• Alberts: Molecular Biology of the Cell, Garland Publishing 2008
• Papers: special papers, see lecture slides for sources
<table>
<thead>
<tr>
<th><strong>Teaching and learning methods</strong></th>
<th>Lecture (2 hours/week)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Workload</strong></td>
<td>30 hours: attendance time</td>
</tr>
<tr>
<td></td>
<td>60 hours: self study and exam preparation</td>
</tr>
<tr>
<td></td>
<td>total: 90 hours</td>
</tr>
<tr>
<td><strong>Assessment</strong></td>
<td>The grade of the module will be the grade of the written exam. No prerequisites are necessary for exam registration.</td>
</tr>
<tr>
<td><strong>Grading procedure</strong></td>
<td>The grade of the module will be the grade of the exam.</td>
</tr>
<tr>
<td><strong>Basis for</strong></td>
<td>Research in the fields of Biophysics</td>
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Graduate Seminar Biophysics and Soft Matter
Modules referring to Elective Courses II - Soft Matter/Biophysics

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<tr>
<td>Attendance time</td>
<td>2</td>
</tr>
<tr>
<td>Language of instruction</td>
<td>English or German</td>
</tr>
<tr>
<td>Duration</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Cycle</td>
<td>each Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Dean of Physics Studies</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Kay Gottschalk, Prof. Jens Michaelis, Prof. Christof Gebhardt</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
<td>Physics M.Sc., elective module, 1st or 2nd semester</td>
</tr>
<tr>
<td></td>
<td>Wirtschaftsphysik M.Sc., elective module, 1st – 3rd semester</td>
</tr>
<tr>
<td>Recommended prerequisites</td>
<td>Course Soft Matter Physics and Biophysics or Biophysics: Fundamentals</td>
</tr>
<tr>
<td>Learning objectives</td>
<td>Students who successfully pass this module</td>
</tr>
<tr>
<td></td>
<td>• are able to read and understand a selected topic in physics from various sources, i.e. scientific books, databases and journals (information competence)</td>
</tr>
<tr>
<td></td>
<td>• have the ability to elaborate and present a scientific topic in a talk within a given time</td>
</tr>
<tr>
<td></td>
<td>• learn to defend their point of view in a scientific discussion</td>
</tr>
<tr>
<td>Syllabus</td>
<td>Students have to elaborate and present a scientific talk on a topic in Biophysics or the field of Soft Matter.</td>
</tr>
<tr>
<td>Literature</td>
<td>• Textbook chapters</td>
</tr>
<tr>
<td></td>
<td>• Review articles</td>
</tr>
<tr>
<td></td>
<td>• Original research articles</td>
</tr>
<tr>
<td><strong>Teaching and learning methods</strong></td>
<td>Seminar (2 hours per week)</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td><strong>Workload</strong></td>
<td>30 hours exercise (attendance time)</td>
</tr>
<tr>
<td></td>
<td>90 hours talk preparation</td>
</tr>
<tr>
<td></td>
<td><strong>Total: 120 hours</strong></td>
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<tr>
<td><strong>Assessment</strong></td>
<td>No english version available yet.</td>
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<tr>
<td><strong>Grading procedure</strong></td>
<td>No english version available yet.</td>
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<tr>
<td><strong>Basis for</strong></td>
<td>Research in the field of Biophysics and Soft Matter Physics</td>
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</table>
Advanced Laboratory Biophysics and Soft Matter

Modules referring to Elective Courses II - Soft Matter/Biophysics

<table>
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<tr>
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<td>ECTS credits</td>
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<td>Attendance time</td>
<td>14</td>
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<td>Language of instruction</td>
<td>English</td>
</tr>
<tr>
<td>Duration</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Cycle</td>
<td>each Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Prof. Dr. K.-E. Gottschalk</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Lecturers of biophysics research</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
<td>Master Advanced Materials, elective module, semester 2 or 3</td>
</tr>
</tbody>
</table>

Recommended prerequisites

Formal prerequisites (according to Study order and examination regulations): none

Prerequisites regarding to the contents: Bachelor's competences in the field related to the subject

Learning objectives

The students who have finished this module successfully,
- earn the skill and competence to work independently on a project in theory and practice in a selected field of biophysics and softmatter research, write it down, discuss it academically in a short treatise, and present it clearly.

Syllabus

In this module the following contents are given:

Practical research project on a topical subject in selected areas of soft matter and biophysics research from the working groups

Literature

- it is made available
- independent literature search is part of the project

Teaching and learning methods

Project work (lab course) soft matter and biophysics research with written elaboration and presentation in the working group or institute
| **Workload**       | Attendance: 180 h  
|                   | preparation & report: 60 h  
|                   | Total: 240 h  |
| **Assessment**    | The award of the credit points for this module is based on completion of an assignment (presentation and paper), active participation in discussions and practical skills. No prerequisites are necessary for exam registration.  |
| **Grading procedure** | The grade of the module will be the grade of the exam.  |
| **Basis for**     | Research in this field  |
Laboratory Principles of Scanning Electron Microscopy
Modules referring to Elective Courses II - Soft Matter/Biophysics

Code 8833273699

ECTS credits 2

Attendance time 1

Language of instruction English

Duration 1 Semester

Cycle each Summer Semester

Coordinator Prof. Dr. K.-E. Gottschalk, Faculty of Natural Science

Instructor(s) Prof. Dr. Ute Kaiser, Faculty of Natural Sciences

Allocation of study programmes Advanced Materials M.Sc., elective module, 2nd Semester

Recommended prerequisites None

Learning objectives Students who have successfully completed this module are able to
• prepare SEM sample
• perform bright-field and dark-field images and diffraction patterns in order to understand the defects in the specimen
• determine the spherical aberration coefficient

Syllabus In this module, the following topics will be covered:
• Modes of SEM operation: imaging, diffraction and spectroscopy
• SEM sample preparation
• Hands-on experience in imaging, diffraction and spectroscopy

Literature Will be announced in the lab course.

Teaching and learning methods Lab Course (equals 2 hours per week)

Workload 30 hours lab course (attendance time)
30 hours self-study and exam preparation
Total: 60 hours

**Assessment**
The award of the credit points for this module is based on regular attendance and a written exam. No prerequisites are necessary for exam registration.

**Grading procedure**
The grade of the module will be the grade of the exam.

**Basis for**
Research in the field of Electron Microscopy
Laboratory Principles of Transmission Electron Microscopy
Modules referring to Elective Courses II - Soft Matter/Biophysics

Code 8822873443

ECTS credits 2

Attendance time 1

Language of instruction English

Duration 1 Semester

Cycle each Winter Semester

Coordinator Dean of Physics Studies

Instructor(s) Prof. Ute Kaiser

Allocation of study programmes Master Advanced Materials, elective module, 3rd Semester

Recommended prerequisites -

Learning objectives Students who have successfully completed the lab course are able to
• prepare a cross-sectional TEM sample
• perform bright-field and dark-field images and diffraction patterns in order to understand the defects in the specimen
• determine the spherical aberration coefficient
• determine the chemical content by EDX analysis

Syllabus In this module, the following topics will be covered:
• Modes of TEM operation: imaging, diffraction and spectroscopy
• TEM sample preparation
• Hands-on experience in imaging, diffraction and spectroscopy
• Determination of the spherical aberration coefficient of the objective lens in an uncorrected TEM, comparison to the aberration-corrected objective lens.

Literature -
<table>
<thead>
<tr>
<th>Teaching and learning methods</th>
<th>1 week TEM Lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workload</td>
<td>Total: 60 h</td>
</tr>
<tr>
<td>Assessment</td>
<td>The grade of the module will be the grade of the written exam. No prerequisites are necessary for exam registration.</td>
</tr>
<tr>
<td>Grading procedure</td>
<td>The grade of the module will be the grade of the exam.</td>
</tr>
<tr>
<td>Basis for</td>
<td>Research in the field of Materials Science and Imaging</td>
</tr>
</tbody>
</table>
Polymeric Materials
Modules referring to Elective Courses II - Soft Matter/Biophysics

Code 8822871305

ECTS credits 3

Attendance time 2

Language of instruction English

Duration 1 Semester

Cycle each Winter Semester

Coordinator Prof. Dr. Ulrich Ziener

Instructor(s) Prof. Dr. Ulrich Ziener

Allocation of study programmes
- Master Chemistry, Study Program Chemistry, compulsory module (Macromolecular Chemistry), 1.-3. semester
- Master Chemistry, Study Program Materials, compulsory module, 1.-3. semester
- Master Chemistry and Management, specialization / Module Group 2 (Macromolecular Chemistry), 1.-3. semester
- Master Advanced Materials, elective, 1.-3. semester

Recommended prerequisites
Formal prerequisites (according to Study order and examination regulations): none

Prerequisites regarding to the contents: Bachelor's competences in the field related to the subject

Learning objectives
Students who have successfully completed this module,
- are able to understand and describe modern applications of organic and macromolecular materials

Syllabus
This module provides the following content:
- Block copolymers for the synthesis of nanoparticles
- Conductive polymers
- Liquid crystalline polymers
- Nanostructuring
- Porous polymeric materials
- Thermoreversible gels
<table>
<thead>
<tr>
<th><strong>Literature</strong></th>
<th>Scientific articles in professional journals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teaching and learning methods</strong></td>
<td>Lecture (2 hours per week)</td>
</tr>
<tr>
<td><strong>Workload</strong></td>
<td>Presence: 30 h</td>
</tr>
<tr>
<td></td>
<td>Private study: 60 h</td>
</tr>
<tr>
<td></td>
<td>Total: 90 h</td>
</tr>
<tr>
<td><strong>Assessment</strong></td>
<td>The grade of the module will be the grade of the oral or written (depending on the number of participants) exam. No prerequisites are necessary for exam registration</td>
</tr>
<tr>
<td><strong>Grading procedure</strong></td>
<td>The grade of the module will be the grade of the exam.</td>
</tr>
<tr>
<td><strong>Basis for</strong></td>
<td>If Macromolecular Chemistry is chosen as the &quot;Fourth Subject&quot;, it is obligatory to pass Polymeric Materials (to complete the respective module group).</td>
</tr>
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</table>
# Principles of Transmission Electron Microscopy and Seminar

**Modules referring to Elective Courses II - Soft Matter/Biophysics**

<table>
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<td>Language of instruction</td>
<td>English</td>
</tr>
<tr>
<td>Duration</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Cycle</td>
<td>each Winter Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Dean of Physics Studies</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Ute Kaiser</td>
</tr>
</tbody>
</table>

## Allocation of study programmes
- Master Advanced Materials, elective module, 3rd Semester

## Recommended prerequisites
- 

## Learning objectives
- Students who have successfully completed the lecture and seminar
  - are able to describe the function of basic components of a transmission electron microscope,
  - are able to understand basic TEM modes, imaging, diffraction and spectroscopy

## Syllabus
- In this module, the following topics will be covered:
  - Components of the TEM including the aberration corrector
  - Physical phenomena of electron-matter interaction

## Literature

## Teaching and learning methods
- Lecture (2 hours per week)
- Exercise (1 h per week)
Workload

30 hours lecture (attendance time)
15 hours seminar (attendance time)
45 hours self-study and exam preparation
Total: 90 hours

Assessment

The grade of the module will be the grade of the oral or written (depending on the number of participants) exam. No prerequisites are necessary for exam registration.

Grading procedure

The grade of the module will be the grade of the exam.

Basis for

Basis for research in field of material science
Smart Materials
Modules referring to Elective Courses II - Soft Matter/Biophysics

Code 8812874199

ECTS credits 3

Attendance time 2

Language of instruction English

Duration 1 Semester

Cycle each Semester

Coordinator Dean of Physics Studies

Instructor(s) Dr. Masoud Amirkhani.

Allocation of study programmes Physics M.Sc., elective module, 1st or 2nd Semester

Recommended prerequisites A basic knowledge about polymers will be sufficient

Learning objectives Responsive soft matter shows significant property changes in response to electrical stimulation, PH and other external stimuli, which can be used as actuator, sensor and energy harvester. These types of materials possess very promising potential to be used for minimally invasive medicine, space and automobile application.

Additionally, soft lithography has been proposed as a cheap and easy method to replace expensive conventional lithography. In this lecture, we will discuss cutting-edge research and technology related to artificial muscles and soft lithography. Furthermore, you will learn the effect of external stimuli on the nanometer and sub-nanometer thick polymeric layer.

Syllabus
• Responsive polymers
• Temperature- and PH-responsive polymers
• Electroactive polymers
• Sensing and actuating
• Soft robotic
• Medical application
• Space application
• Soft nanolithography
• Phase separation of block copolymers
• External stimuli
• Nanometer and sub-nanometer polymers on surface
**Literature**

- Electroactive Polymers for Robotic Applications Artificial Muscles and Sensors, Kwang J. Kim and Satoshi Tadokoro
- Biomedical Applications of Electroactive Polymer Actuators, Federico Carpi, Elisabeth Smela
- Electroactive Polymer Gel Robots Modelling and Control of Artificial Muscles, Mihoko Otake

**Teaching and learning methods**

Lecture 2 h/week

**Workload**

30 h Lecture (Attendance)
60 h Self study and exam preparation
Total: 90 h

**Assessment**

The grade of the module will be the grade of the oral exam. Prerequisite for exam registration is passing the pre-course. The specific form and extent of the exam as well as the exact type of the obligatory pre-course will be determined and announced by the lecturer at the beginning of the semester.

**Grading procedure**

The grade of the module will be the grade of the exam.

**Basis for**

Research project in Biophysics and experimental Physics.
Advanced Biology
Modules referring to Compulsory Modules

Code 8822873025

ECTS credits 10

Attendance time 6

Language of instruction English

Duration 1 Semester

Cycle each Summer Semester

Coordinator Dean of Studies Physics

Instructor(s) Prof. Dr. C. Gebhardt, Faculty of Natural Science

Allocation of study programmes MSc Advanced Materials, Biomaterials

Recommended prerequisites none

Learning objectives No English version available yet.

Syllabus Physics of Soft Matter and Biophysics
- The cell and its components
- Biological macromolecules: proteins, nucleic acids, bio membranes
- Transportation processes
- Thermodynamics of structure formation in biological systems, equilibriums and reactions, cooperativeness
- Function description of molecular machines
- Model description of Polymers

Literature
| **Teaching and learning methods** | Lecture 3 h/week  
Exercise 1 h/week  
Seminar 1 h/week |
|---|---|
| **Workload** | 45 hours lecture (attendance time)  
15 hours exercise (attendance time)  
15 hours seminar (attendance time)  
75 hours self-study and exam preparation  
Total: 150 hours |
| **Assessment** | The module will be passed once the written or oral (depending on the number of participants) exam and practical work have been passed. |
| **Grading procedure** | The grade of the module will be the grade of the exam. |
| **Basis for** | MSc Advanced Materials, Biomaterials |
# Biology

Modules referring to Compulsory Modules

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<td>Attendance time</td>
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<tr>
<td>Language of instruction</td>
<td>English</td>
</tr>
<tr>
<td>Duration</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Cycle</td>
<td>each Winter Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Prof. Dr. K.-E. Gottschalk</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Dr. Paul Walther, PD Dr. Andres Ziegler; Dr. Tamas Röszer</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
<td>MSc Advanced Materials, semester 1</td>
</tr>
<tr>
<td>Recommended prerequisites</td>
<td>Fundamentals of Biology</td>
</tr>
</tbody>
</table>

## Learning objectives

Students should be able to
- understand central problems of biology and cell biology.
- understand links between different fields of biosciences.
- follow the Biomaterials lectures in 2nd and 3rd semester.

## Syllabus

**Biomolecules**
- Water and the fitness of the environment
- Carbon and the molecular diversity of life
- Major classes of biomolecules
- Structure and function of macromolecules
- Introduction to metabolism, enzymes

**Cell morphology and gene expression**
- A tour of the cell
- Membrane structure and function
- The cell cycle
- The molecular basis of inheritance
- From gene to protein
- Regulation of gene expression

**Intracellular compartments and protein sorting**
- Vesicular transport
- Cytoskeleton and mitosis

**Cellular respiration**
- Harvesting chemical energy
Structure and function of cellular membranes
  - Cell-cell contacts and cell adhesion
  - Cell-environment interactions
  - Sensing
  - Structure and function of the extracellular matrix
Cellular model systems
  - Development
  - Animal development
  - Development genes and their detection
Functional anatomy
  - Muscle function
  - Nervous system
  - Tissues
Endocrinology
  - Chemical signals in animals
  - Blood glucose and adrenal gland hormones in non-vertebrates
Circulation and gas exchange
  - Circulation and gas exchange
  - Gas exchange in animals

**Literature**
- Handouts

**Teaching and learning methods**
Lecture, 4 h/week

**Workload**
Total 150 h
64 h presence
70 h preparation and post-processing
16 h exam preparation

**Assessment**
The grade of the module will be the grade of the oral or written (depending on the number of participants) exam. No prerequisites are necessary for exam registration.

**Grading procedure**
The grade of the module will be the grade of the exam.

**Basis for**
MSc Advanced Materials
## Biomaterials in Medicine

Modules referring to Compulsory Modules

<table>
<thead>
<tr>
<th>Code</th>
<th>8822874163</th>
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<tbody>
<tr>
<td>ECTS credits</td>
<td>5</td>
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<tr>
<td>Attendance time</td>
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<tr>
<td>Language of instruction</td>
<td>English</td>
</tr>
<tr>
<td>Duration</td>
<td>1 Semester</td>
</tr>
<tr>
<td>Cycle</td>
<td>each Summer Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Prof. Dr. med. Rolf Brenner; Medical School</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Dr. med. R. Brenner and lecturers of Medical School</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
<td>MSc Advanced Materials, semester 2, Biomaterials</td>
</tr>
<tr>
<td>Recommended prerequisites</td>
<td>Module Biology</td>
</tr>
</tbody>
</table>
| Learning objectives               | Students should be able to  
- give an overview on human tissues (structure and properties) that can be replaced or supported by synthetic materials and devices  
- describe and analyze relevant properties of currently used biomaterials  
- outline current fields of application for biomaterials  
- discuss the demands and risks for new biomaterials as resulting from clinical problems |

### Syllabus

1. Biological tissues to be replaced/supported by biomaterials (tissue composition, structure, properties and function)
   - Cartilage
   - Tendon and ligament
   - Bone
   - Teeth
   - Skin
   - Blood vessels and heart
   - Blood
   - Kidney
   - Liver and pancreas
• Eyes

2. Biomaterials used to replace/support biological tissues
(chemical composition, mechanical and biological properties, processing)
• Polymers
• Ceramics
• Metals
• Hydrogels
• Natural materials
• Composites

3. Applications of Biomaterials (dental, orthopedic, trauma, cardiovascular, plastic surgery, ophthalmology)
• Drug-delivery
• Materials for bone, cartilage and ligament replacement
• Materials for tooth repair
• Blood and blood vessels replacement
• Artificial liver and pancreas
• Eyes, eye implants

Literature

Teaching and learning methods
Lecture, 4 h/week

Workload
Total 150 h
56 h presence

Assessment
The grade of the module will be the grade of the written exam. No prerequisites are necessary for exam registration.

Grading procedure
The grade of the module will be the grade of the exam.

Basis for
MSc Advanced Materials, Biomaterials
Chemistry
Modules referring to Compulsory Modules

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<td>Cycle</td>
<td>each Winter Semester</td>
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<tr>
<td>Coordinator</td>
<td>Prof. Dr. Thorsten M. Bernhardt, Faculty of Natural Sciences</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Dr. Thorsten M. Bernhardt, Faculty of Natural Sciences</td>
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<td>Recommended prerequisites</td>
<td>Fundamentals in Chemistry</td>
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<td>Learning objectives</td>
<td>Physical Chemistry</td>
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<tr>
<td></td>
<td>Students should be able</td>
</tr>
<tr>
<td></td>
<td>- to apply the laws and principles of thermodynamics and of reaction kinetics when analyzing chemical reactions with respect to energy conversion, equilibrium and reaction rate.</td>
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<tr>
<td>Syllabus</td>
<td>Physical Chemistry</td>
</tr>
<tr>
<td></td>
<td>- Thermodynamics: The laws of thermodynamics, enthalpy, entropy, free-energy, absolute zero of temperature, applications to chemical reactions, chemical equilibrium.</td>
</tr>
<tr>
<td></td>
<td>- Reaction kinetics: Reaction rate / rate equation, reaction order, dependence of reaction rate on temperature, activation energy, catalysis.</td>
</tr>
<tr>
<td></td>
<td>- Quantum chemistry: Properties of waves and the wave-nature of matter, atomic structure and orbital theory, atomic orbitals (hydrogen atom) and molecular orbitals, principles of chemical bond formation.</td>
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</table>
- Spectroscopy: Basic spectroscopy techniques in chemistry.

**Literature**

**Teaching and learning methods**
- Lecture 4 h/week
- Problem solving 1h/week

**Workload**
- Total: 120 h
- Lecture: 64 h presence
- Problem solving: 16 h presence
- 24 h preparation and post processing
- Exam: 16 h preparation

**Assessment**
The grade of the module will be the grade of the written exam. Prerequisite for exam registration is passing the pre-course (to be defined by the examiner).

**Grading procedure**
The grade of the module will be the grade of the exam.

**Basis for**
MSc Advanced Materials
## Materials and Engineering Science

Modules referring to Compulsory Modules

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<td>Cycle</td>
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<tr>
<td>Coordinator</td>
<td>Prof. Dr. U. Herr, Faculty of Engineering, Computer Science and Psychology</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Dr. U. Herr, Faculty of Engineering, Computer Science and Psychology Prof. Dr. F. Scholz, Faculty of Engineering, Computer Science and Psychology</td>
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<td>Fundamentals of mathematics, physics and chemistry</td>
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<td>Materials Science I</td>
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**Students should be able to**

- classify metallic, ceramic and polymeric materials based on their structure on the atomic scale, microstructure and macroscopic properties.
- analyze different materials with respect to mechanical strength.
- understand the physical basis for thermal, electrical and magnetic properties of solid materials.

**Electrical Engineering**

**Students should be able to**

- perform circuit analysis of linear DC and AC (RLC) circuits.
- explain the basics of semiconductor physics.
- explain how basic semiconductor devices work.
- handle and evaluate measured data on a basic level.
- convert analogue data into digital data.
- handle digital data.
- specify advantages and problems of digital data processing.
- Classification of materials with respect to chemical bond and structure.
- Crystal structure: Symmetry classes, lattices, reciprocal lattice, diffraction.
- Defects in solids: Point defects, dislocations, grain and phase boundaries.
- Characterization of the microstructure: Microscopic methods (optical, SEM), diffraction techniques (XRD, TEM), scanning probe techniques (introduction).
- Phase diagrams: Thermodynamics of solutions, chemical potential, phase equilibrium, basic types of phase diagrams, important examples.
- Transport: Diffusion (macroscopic and microscopic description), diffusion at surfaces and interfaces, electromigration, therмотransport.
- Phase transformations: Thermodynamics and kinetics, diffusive transformations, non-diffusive transformations.
- Mechanical properties: Elasticity, plastic deformation, viscous flow and creep, fracture.

Electrical Engineering

- Circuit analysis: Network analysis, Thevenin and Norton equivalent circuits, superposition principle, linearity, capacitors & inductors, transformers
- Analysis of transients: Frequency analysis, filters etc.: Frequency response, logarithmic scale, Bode diagram, low pass, high pass, 2nd order low pass etc.
- Fourier and Laplace transformation: Transfer function, step, pulse response, convolution
- Semiconductors: Band structure, density of states, Fermi statistics, impurity conduction, mobility, diffusion. Hall effect
- Diodes: p-n-junction, load line analysis, pn as capacitance, Schottky diode
- Transistors: Bipolar transistor (band structure, common base, common emitter, amplification), Field Effect Transistor (Structure, operation, enhancement and depletion); load line analysis
- Devices for measurement: Operational amplifier, basics, adder, subtractor, integrator, differentiator, logarithmiser
- Probability distribution functions: Binomial, Poisson, Gauss
- Signal filtering, noise: Thermal, shot, 1/f, distribution, generation-recombination
- Digital Signal Processing: basic logic operations, adders, flip-flop,
- Digitization: Basics, sampling theorem, DA and AD converters, Digital filters, z-transformation

Literature

Materials Science I


Electrical Engineering


<table>
<thead>
<tr>
<th>Teaching and learning methods</th>
<th>Materials Science I</th>
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</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>3 h/week</td>
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<tr>
<td>Solving problems</td>
<td>1 h/week</td>
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<td>Electrical Engineering</td>
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<tr>
<td>Lecture</td>
<td>3 h/week</td>
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<tr>
<td>Solving problems</td>
<td>1 h/week</td>
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<thead>
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<th>Workload</th>
<th>Materials Science I</th>
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<td>Lecture:</td>
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<td>38 h preparation and revision</td>
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<td>Solving problems:</td>
<td>16 h presence</td>
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<td>32 h revision</td>
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<td>Exam:</td>
<td>16 h preparation</td>
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<table>
<thead>
<tr>
<th>Workload</th>
<th>Electrical Engineering</th>
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<tbody>
<tr>
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<td>32 h revision</td>
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<tr>
<td>Exam:</td>
<td>16 h preparation</td>
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<tr>
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<th>The grade of the module will be the grades of the written exams. No prerequisites are necessary for exam registration.</th>
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<th>Grading procedure</th>
<th>The grade of the module will be the average of the individual exam grades weighted by the credit points of the individual exams.</th>
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| Basis for | MSc Advanced Materials, Focus Nanomaterials, Materials Science Lab and Advanced Materials Science |
## Materials Chemistry

**Modules referring to Compulsory Modules**

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<tr>
<td>Cycle</td>
<td>each Summer Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Prof. K.-E. Gottschalk, Faculty of Natural Sciences</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Prof. Dr. Max Fichtner, Dr. Elena Mena-Osteritz</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
<td>MSc Advanced Materials, semester 2</td>
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<tr>
<td>Recommended prerequisites</td>
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<tr>
<td>Learning objectives</td>
<td>Students should be able to</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Chemistry of Inorganic Solids:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- describe the structure, bonding and the electronic structure of an inorganic solid</td>
</tr>
<tr>
<td></td>
<td>- decide which method of characterization can be applied for different inorganic solid materials</td>
</tr>
<tr>
<td></td>
<td>- describe basic synthetic methods for the fabrication of inorganic materials</td>
</tr>
<tr>
<td></td>
<td>- correlate the electrical, optical and magnetic properties of the material with its nanostructure, defect structure</td>
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<tr>
<td></td>
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<tr>
<td>b) Organic Materials</td>
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<tr>
<td></td>
<td>- describe the fundamentals in organic materials formation</td>
</tr>
<tr>
<td></td>
<td>- represent and understand the different classes of organic materials</td>
</tr>
<tr>
<td></td>
<td>- describe the application’s spectrum in material chemistry</td>
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### Syllabus

**Materials Chemistry**

<table>
<thead>
<tr>
<th>a) Solid State Chemistry:</th>
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<tbody>
<tr>
<td>Structure of solids, basic crystallography, characterization of solids</td>
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</table>
Bonding in solids, Real structure of crystals. Solid state reaction, sol-gel method, hydrothermal synthesis, vapor phase transport, methods for crystal growth, structure-property relations.

**b) Organic Materials and Structure Formation**

*including Inorganic Chemistry: Atoms, Hydrogen, Halogens, Chalcogens*

*Interactions:* Van der Waals, interaction forces, electrostatic interaction between systems.

<table>
<thead>
<tr>
<th>Literature</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Teaching and learning methods</th>
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<tbody>
<tr>
<td>Lecture 3 h/week</td>
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<table>
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<tr>
<th>Workload</th>
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<tbody>
<tr>
<td>42 h lecture (presence)</td>
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<td>62 h preparation and post processing</td>
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<tr>
<td>16 h exam preparation</td>
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<table>
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<th>Assessment</th>
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<tbody>
<tr>
<td>The grade of the module will be the grade of the written exam. No prerequisites are necessary for exam registration.</td>
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<thead>
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<table>
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<tbody>
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<td>MSc Advanced Materials</td>
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### Mathematics

Modules referring to Compulsory Modules

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<td>Language of instruction</td>
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<tr>
<td>Duration</td>
<td>1 Semester</td>
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<tr>
<td>Cycle</td>
<td>each Winter Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Prof. Dr. K.-E. Gottschalk, Faculty of Natural Sciences</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Dr. Vincenzo Tamma, Faculty of Natural Sciences</td>
</tr>
</tbody>
</table>

#### Allocation of study programmes

- MSc Advanced Materials, semester 1

#### Recommended prerequisites

- Fundamentals of mathematics

#### Learning objectives

This course gives an overview of essential mathematical methods for the solution of generic problems in Physics and related subjects. Specific examples of important physical applications will be given. The course aims to provide the student with the expected mathematical competency for further courses in different areas of Physics and related subjects.

#### Syllabus

- Ordinary differential equations and systems of differential equations
- Linear vector spaces, Vector and Matrix Analysis
- Fourier Analysis
- Functions of complex variable and integral calculus

#### Literature

Bibliographical references will be given to the students for each different topic addressed in the course.

#### Teaching and learning methods

- Lecture 3h/week
- Problem solving 2h/week
| **Workload**         | 48 h presence  
|                     | 16 h preparation and revision  
| Solving problems:   | 32 h presence  
|                     | 64 h preparation and revision  
| Exam:               | 16 h preparation  
| **Assessment**      | The grade of the module will be the grade of the oral or written (depending on the number of participants) exam. No prerequisites are necessary for exam registration.  
| **Grading procedure** | The grade of the module will be the grade of the exam.  
| **Basis for**       | MSc Advanced Materials  

Physics I
Modules referring to Compulsory Modules

**Code** 8822872896

**ECTS credits** 10

**Attendance time** 6

**Language of instruction** English

**Duration** 1 Semester

**Cycle** each Semester

**Coordinator** Prof. Dr. K.-E. Gottschalk, Faculty of Natural Sciences

**Instructor(s)** Prof. Dr. U. Herr; Faculty of Engineering, Computer Science and Psychology
Dr. L. Rogers, Faculty of Natural Sciences

**Allocation of study programmes** MSc Advanced Materials, semester 1 and 2

**Recommended prerequisites** Fundamentals of physics (mechanics, electricity, optics, quantum mechanics) and Fundamentals of mathematics (differentiation, integration, complex calculus, ordinary and partial differential equations)

**Learning objectives** Physics I
Students should be able to
- relate the atomic structure of materials to physical properties.
- classify materials according to atomic structure and involved chemical bonds.
- describe electrons in a solid state system: atom vs. solid.
- describe lattice vibrations and their influence on material properties: classical vs. quantum mechanical description, statistics of bosons.
- explain optical properties of dielectrics and metals by microscopic models.
- understand that classical physics often fails to predict material properties and quantum effects have to be taken into account.

Physics Lab
Students be able to
- determine basic properties of a solid experimentally by
  - structure analysis by X-ray diffraction
  - electronic core level analysis by X-ray photoelectron spectroscopy
  - electric conductivity measurement.
- use cryostats to perform experiments at low temperature.
- design and carry out advanced experiments in solid state physics.
- write scientific lab reports.
Syllabus

Physics I
- Basic classification of solids by means of structure, bonds and properties.
- Experimental determination of structure.
- Lattice vibrations and phonons: specific heat.
- Properties of the electron shell in solids, free electrons.
- Optical properties of solids.

Physics Lab
- Specific heat of simple metals between 2 K and 20 K
- Advanced measurement techniques: Application of a Lock-in amplifier
- Determination of electrical conductivity of metals and semiconductors between 2 K and 70 K
- X-ray photoelectron spectroscopy (XPS) on Au and Au2O3
- Optical properties of Au films and Au nanoparticles.

Literature

Physics I

Physics Lab

Handouts

Teaching and learning methods

Physics I
Lecture 3 h/week
Tutorial/Problem solving 4 x 2h

Physics Lab
4 h/week

Workload

Physics I Total 150 h
Lecture: 48 h lecture
68 h preparation and post-processing
Seminar: 8 h presence
8 h solving problems, revision
Exam: 2 h exam + 16 h preparation

Physics Lab Total 120 h
20 h laboratory (presence)
20 h preparation
80 h revision, writing reports

Assessment

The module will be passed once the written or oral (depending on the number of participants) exam and practical work have been passed.
<table>
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<tr>
<th>Grading procedure</th>
<th>The grade of the module will be the average of the individual exam grades weighted by the credit points of the individual exams.</th>
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<tbody>
<tr>
<td>Basis for</td>
<td>MSc Advanced Materials</td>
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## Scientific Method Training

Modules referring to Compulsory Modules

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<td>Duration</td>
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<tr>
<td>Cycle</td>
<td>each Winter Semester</td>
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<tr>
<td>Coordinator</td>
<td>Prof. Dr. K.-E. Gottschalk, Faculty of Natural Sciences</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Dr. C. Röcker, Faculty of Natural Sciences</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
<td>MSc Advanced Materials, semester 1</td>
</tr>
<tr>
<td>Recommended prerequisites</td>
<td>Fundamental knowledge of lab work</td>
</tr>
<tr>
<td>Learning objectives</td>
<td>Practical experience in basic physical experimental techniques relevant for Biophysics and analysis of experimental data with critical discussion.</td>
</tr>
</tbody>
</table>
| Syllabus        | • Mechanical oscillations  
|                  | • Thermic radiation  
|                  | • Optical interference and spectrometry  
|                  | • Oscillating electric circuits |
| Literature      | Lab Manual |
| Teaching and learning methods | Lab work with full-day experiments including introductory and final discussions. |
| Workload        | 45 hours laboratory course (attendance time)  
|                  | 75 hours self-study, data analysis, report writing  
|                  | Total: 120 hours |
| **Assessment** | The grade of the module will be the grade of the oral or written (depending on the number of participants) exam. No prerequisites are necessary for exam registration. |
| **Grading procedure** | The grade of the module will be the grade of the exam. |
| **Basis for** | MSc Advanced Materials |
## Additive Key Qualifications

Modules referring to Additive Key Qualifications

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<td>Syllabus</td>
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<td>Workload</td>
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### Additive Key Qualifications

Modules referring to Additive Key Qualifications

<table>
<thead>
<tr>
<th><strong>Code</strong></th>
<th>8822870973</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ECTS credits</strong></td>
<td>8</td>
</tr>
<tr>
<td><strong>Attendance time</strong></td>
<td>10</td>
</tr>
<tr>
<td><strong>Language of instruction</strong></td>
<td>Depends on chosen course</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>1 Semester</td>
</tr>
<tr>
<td><strong>Cycle</strong></td>
<td>each Semester</td>
</tr>
<tr>
<td><strong>Coordinator</strong></td>
<td>Leader of the language center of the University of Ulm Instructor(s)</td>
</tr>
<tr>
<td><strong>Instructor(s)</strong></td>
<td>Leader of the language center of the University of Ulm Instructor(s)</td>
</tr>
<tr>
<td><strong>Allocation of study programmes</strong></td>
<td>Master Advanced Materials, compulsory module, 1.-3. Semester</td>
</tr>
<tr>
<td><strong>Recommended prerequisites</strong></td>
<td>Formal prerequisites (according to Study order and examination regulations): none</td>
</tr>
<tr>
<td><strong>Learning objectives</strong></td>
<td>Intercultural competence and foreign linguistic knowledge; knowledge and abilities in the areas of work in the team, communication and presentation; reflecting competence, communication competence and argumentation competence.</td>
</tr>
<tr>
<td><strong>Syllabus</strong></td>
<td>Depends on the chosen course</td>
</tr>
<tr>
<td><strong>Literature</strong></td>
<td>Is made available in the chosen course</td>
</tr>
<tr>
<td><strong>Teaching and learning methods</strong></td>
<td>in general: seminar (2 hours per week)</td>
</tr>
</tbody>
</table>
| **Workload** | Presence study: 30 H  
Self study: 60 H  
Total: 90 H |
<table>
<thead>
<tr>
<th><strong>Assessment</strong></th>
<th>see separate sub modules</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grading procedure</strong></td>
<td>The grade of the module will be the average of the individual exam grades weighted by the credit points of the individual exams.</td>
</tr>
<tr>
<td><strong>Basis for</strong></td>
<td>none</td>
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# German Language

Modules referring to Additive Key Qualifications

<table>
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<tbody>
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<tr>
<td>Attendance time</td>
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</tr>
<tr>
<td>Language of instruction</td>
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</tr>
<tr>
<td>Duration</td>
<td>3 Semester</td>
</tr>
<tr>
<td>Cycle</td>
<td>each Semester</td>
</tr>
<tr>
<td>Coordinator</td>
<td>Dr. Timm, Centre for Languages and Philology</td>
</tr>
<tr>
<td>Instructor(s)</td>
<td>Lecturers from from Centre for Languages and Philology</td>
</tr>
<tr>
<td>Allocation of study programmes</td>
<td>MSc Advanced Materials, semester 1,2,3</td>
</tr>
<tr>
<td>Recommended prerequisites</td>
<td>None</td>
</tr>
<tr>
<td>Learning objectives</td>
<td>Development of language skills: Listening, speaking, reading, writing. Depending on the students language level a specific course is chosen, the courses may cover approx. 1 level of the CEFR. German for Advanced Material, Energy Science and Technology and Finance 1 to 3. Level A1, CEFR (Common European Framework of Reference for Languages). Students should be able to: - understand and use familiar, everyday expressions and very simple sentences, which relate to the satisfying of concrete needs. - introduce him/herself and others as well as ask others about themselves – e.g. where they live, who they know and what they own – and can respond to questions of this nature. - communicate in a simple manner if the person they are speaking to speaks slowly and clearly and is willing to help. Level A2, CEFR</td>
</tr>
</tbody>
</table>
Students should be able to

- understand sentences and commonly used expressions associated with topics directly related to his/her direct circumstances (e.g. personal information or information about his/her family, shopping, work, immediate surroundings).
- make him/herself understood in simple, routine situations dealing with a simple and direct exchange of information on familiar and common topics.
- describe his/her background and education, immediate surroundings and other things associated with immediate needs in a simple way.

Level B1 and above, CEFR

Students should be able to

- understand the main points when clear, standard language is used and the focus is on familiar topics associated with work, school, leisure time, etc.
- deal with most situations typically encountered when travelling in the language region.
- express him/herself simply and coherently regarding familiar topics and areas of personal interest.
- report on experiences and events, describe dreams, hopes and goals as well as make short statements to justify or explain his/her own views and plans.

**Syllabus**

For the three courses alike:

- vocabulary training
- grammar training
- development of communication skills

**Literature**

Menschen – Deutsch als Fremdsprache, Max Hueber Verlag, 2013. Kursbuch A1, A2 and B1

Sicher – Deutsch als Fremdsprache, Max Hueber Verlag, 2013. Kursbuch B1+

**Teaching and learning methods**

4 hours per week

**Workload**

Semester 1 and 2

Lecture 60 h
Preparation 30 h

Semester 3

Lecture 30 h
Preparation 30 h

**Assessment**

The module will be passed once all three exams have been passed.
**Grading procedure**  The grade of the module will be the average of the individual exam grades weighted by the credit points of the individual exams.

**Basis for**  

## Master's Thesis

### Modules referring to Master Thesis

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<th><strong>Code</strong></th>
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</tr>
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<tbody>
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<td>30</td>
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<tr>
<td><strong>Attendance time</strong></td>
<td>30</td>
</tr>
<tr>
<td><strong>Language of instruction</strong></td>
<td>English</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>1 Semester</td>
</tr>
<tr>
<td><strong>Cycle</strong></td>
<td>each Semester</td>
</tr>
<tr>
<td><strong>Coordinator</strong></td>
<td>Prof. Dr. K.-E. Gottschalk, Faculty of Natural Sciences</td>
</tr>
<tr>
<td><strong>Instructor(s)</strong></td>
<td>Examiners of Faculty of Natural Sciences or Computer Science, Engineering and Psychology or Medicine.</td>
</tr>
</tbody>
</table>

### Allocation of study programmes

| **MSc Advanced Materials, semester 4** |

### Recommended prerequisites

| **Formal prerequisites (according to Study order and examination regulations)** |

**Prerequisites regarding to the contents:** Thematically relevant modules and lectures of the master course of studies

Research project to be carried out at an institute or institution of Ulm University

On request, it may be performed at a research institution not belonging to Ulm University or with a company engaged in research, development or production of modern functional materials.

The registration of the module must be carried out with board of examiners with the form intended for it!

### Learning objectives

| **Students who successfully passed this module** |

- have learned to integrate in a research team
- are able to investigate a topic in the current research in nanomaterials or biomaterials independently and according to the rules of good scientific practice, and to develop their own approach
- can prove and document their findings on scientific principles
- are able to motivate their solutions and defend their thesis in a scientific discussion
### Syllabus
- Execution of a theoretical or experimental research project
- Analysis and evaluation of the obtained results
- Discussion of the results in the context of the relative literature
- Documentation of the research project

### Literature
- Literature search is part of the assignment

### Teaching and learning methods
- Independent scientific work, professional discussions, working group seminars or seminars in the enterprise (28 CP)
- Presentation of the results of the work (2 CP); the presentation is public (working group, institute, faculty)

### Workload
- For literature work, experimental works and documentation: 900 h

### Assessment
- Written master's thesis and oral presentation of the results of the master's thesis.

### Grading procedure
- The grade of the module will be the grade of the exam. The module grade is based on the grades of the written master's thesis (28 credit points) and the presentation (2 credit points). The Transcript of Records only shows the calculated overall grade as an exam achievement.

### Basis for
- PhD