Module Handbook
Optics and Photonics Master 20151 (Master of Science (M.Sc.))
SPO 20151
Winter term 2022/23
Date: 24/10/2022

KIT DEPARTMENT OF ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY
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<td>X-Ray Optics</td>
<td>3 CR</td>
</tr>
<tr>
<td>M-ETIT-100475</td>
<td>Plastic Electronics / Polymerelectronics</td>
<td>3 CR</td>
</tr>
<tr>
<td>M-CHEMBIO-101901</td>
<td>Advanced Inorganic Materials</td>
<td>3 CR</td>
</tr>
<tr>
<td>M-PHYS-102146</td>
<td>Nano-Optics</td>
<td>8 CR</td>
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<tr>
<td>M-PHYS-103093</td>
<td>Quantum Optics</td>
<td>6 CR</td>
</tr>
<tr>
<td>M-PHYS-103089</td>
<td>Computational Photonics, without ext. Exercises</td>
<td>6 CR</td>
</tr>
<tr>
<td>M-ETIT-103270</td>
<td>Optical Networks and Systems</td>
<td>4 CR</td>
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<tr>
<td>M-ETIT-103802</td>
<td>Adaptive Optics</td>
<td>3 CR</td>
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<tr>
<td>M-PHYS-102295</td>
<td>Theoretical Nanooptics</td>
<td>6 CR</td>
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<td>M-ETIT-105914</td>
<td>Photonic Integrated Circuit Design and Applications</td>
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1.12 Specialization - Biomedical Photonics

**Compulsory Modules (Election: at least 5 credits)**

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**Compulsory Elective Modules (Election: at least 11 credits)**

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<tr>
<td>M-PHYS-102146</td>
<td>Nano-Optics</td>
<td>8 CR</td>
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<tr>
<td>M-PHYS-102194</td>
<td>Research Project</td>
<td>4 CR</td>
</tr>
<tr>
<td>M-CHEMBIO-101907</td>
<td>Organic Photochemistry</td>
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<td>M-CHEMBIO-101905</td>
<td>Imaging Techniques in Light Microscopy</td>
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<tr>
<td>M-CHEMBIO-101906</td>
<td>Optics and Vision in Biology</td>
<td>4 CR</td>
</tr>
<tr>
<td>M-ETIT-103252</td>
<td>Optical Systems in Medicine and Life Science</td>
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<td>M-ETIT-103802</td>
<td>Adaptive Optics</td>
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1.13 Specialization - Optical Systems

**Specialization - Optical Systems (Election: at least 16 credits)**

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<td>Optical Transmitters and Receivers</td>
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<td>M-ETIT-100506</td>
<td>Optical Waveguides and Fibers</td>
<td>4 CR</td>
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<tr>
<td>M-ETIT-100512</td>
<td>Light and Display Engineering</td>
<td>4 CR</td>
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<tr>
<td>M-ETIT-100537</td>
<td>Systems and Software Engineering</td>
<td>5 CR</td>
</tr>
<tr>
<td>M-ETIT-100566</td>
<td>Field Propagation and Coherence</td>
<td>4 CR</td>
</tr>
<tr>
<td>M-ETIT-100577</td>
<td>Lighting Design - Theory and Applications</td>
<td>3 CR</td>
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<tr>
<td>M-PHYS-102194</td>
<td>Research Project</td>
<td>4 CR</td>
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<td>M-MACH-101923</td>
<td>Machine Vision</td>
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<td>Plastic Electronics / Polymerelectronics</td>
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<tr>
<td>M-PHYS-103093</td>
<td>Quantum Optics</td>
<td>6 CR</td>
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<tr>
<td>M-PHYS-103089</td>
<td>Computational Photonics, without ext. Exercises</td>
<td>6 CR</td>
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<tr>
<td>M-ETIT-103252</td>
<td>Optical Systems in Medicine and Life Science</td>
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<td>Automotive Vision</td>
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<td>Optical Networks and Systems</td>
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<td>M-ETIT-103450</td>
<td>Digital Signal Processing in Optical Communications – with Practical Exercises</td>
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<tr>
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<td>Introduction to Automotive and Industrial Lidar Technology</td>
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### 1.14 Specialization - Solar Energy

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<td>M-ETIT-101917</td>
<td>Electric Power Generation and Power Grid</td>
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<td>M-PHYS-102408</td>
<td>Solid-State Optics</td>
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<tr>
<td>M-ETIT-100475</td>
<td>Plastic Electronics / Polymerelectronics</td>
<td>3</td>
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<tr>
<td>M-PHYS-102146</td>
<td>Nano-Optics</td>
<td>8</td>
</tr>
<tr>
<td>M-PHYS-103089</td>
<td>Computational Photonics, without ext. Exercises</td>
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<tr>
<td>M-MACH-101924</td>
<td>Solar Thermal Energy Systems</td>
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### 1.15 Specialization - Quantum Optics & Spectroscopy

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<td>Research Project</td>
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<td>M-PHYS-102408</td>
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<td>M-CHEMBIO-101901</td>
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<td>Molecular Spectroscopy</td>
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<td>M-PHYS-103093</td>
<td>Quantum Optics</td>
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<td>Adaptive Optics</td>
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<td>M-PHYS-104092</td>
<td>Quantum Optics at the Nano Scale: Basics and Applications, with Exercises</td>
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<td>M-PHYS-104094</td>
<td>Quantum Optics at the Nano Scale: Basics and Applications, without Exercises</td>
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<td>M-ETIT-105914</td>
<td>Photonic Integrated Circuit Design and Applications</td>
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## 1.16 Additional Examinations

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<td>Light and Display Engineering</td>
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<td>Systems and Software Engineering</td>
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<td>M-ETIT-100577</td>
<td>Lighting Design - Theory and Applications</td>
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<td>Machine Vision</td>
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2 Modules

2.1 Module: Adaptive Optics [M-ETIT-103802]

<table>
<thead>
<tr>
<th>Responsible:</th>
<th>Prof. Dr. Ulrich Lemmer</th>
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<tbody>
<tr>
<td>Organisation:</td>
<td>KIT Department of Electrical Engineering and Information Technology</td>
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<tr>
<td>Part of:</td>
<td>Specialization - Photonic Materials and Devices</td>
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<td>Specialization - Biomedical Photonics (Compulsory Elective Modules)</td>
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<td></td>
<td>Specialization - Optical Systems</td>
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<td>Specialization - Quantum Optics &amp; Spectroscopy</td>
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| Credits | 3 |
| Grading scale | Grade to a tenth |
| Recurrence | Each winter term |
| Duration | 1 term |
| Language | English |
| Level | 4 |
| Version | 3 |

Mandatory

| T-ETIT-107644 | Adaptive Optics | 3 CR |

 Competence Certificate
Type of Examination: Oral examination

Duration of Examination: approx. 30 Minutes

Modality of Exam: The oral exam will be scheduled during the semester break.

Prerequisites
None.

Competence Goal
The students will:

- get familiar with Fourier description of imaging through aberrated optical systems and random media,
- understand the description of aberrations through Zernike modes,
- learn how to analytically compute the effects of turbulence on various optical observables such as image/beam motion, temporal power spectra, Zernike modes, scintillation, etc.,
- understand the effect of noise on various quantities and metrics pertinent to the design of adaptive optical systems,
- understand the advantages and disadvantages of various schemes for wavefront sensing and correction,
- learn how to simulate and design simple adaptive optics systems.

Content
Adaptive optics is a technology of correcting the effect of atmospheric turbulence on images of space objects and on laser beams propagating through random and highly aberrated media such as turbulence, tissue, and the inside of the human eye, to name just a few applications. The course will familiarize the students with theoretical basics of light propagation through random media, principles of wavefront sensing and reconstruction, as well as wavefront correction with deformable mirrors. The students will also receive solid introduction to statistical optics, the Kolmogorov theory of turbulence, practical aspects of turbulence simulation and modelling of adaptive optics.

1. Theory of turbulence (covariances, structure functions, power spectra, inertial range, dimensional argument of Kolmogorov)
2. Fourier optics (point-spread function, modulation transfer function)
3. Statistical optics (characteristic function, probability density function)
4. Sources and description of aberrations (Zernike polynomials, orthogonality, Marechal criterion)
5. Adaptive optics systems (open- and closed-loop systems, error budgets, tip-tilt correction)
6. Wavefront sensing (Shack-Hartmann wavefront sensor, wavefront reconstruction, wavefront-sensorless AO)
7. Wavefront correction (tip-tilt mirrors, deformable mirrors, piezoelectric effect, microelectromechanical systems, electrostatic actuation)
8. Simulation of adaptive optical systems (analytic vs. end-to-end modelling)
9. Propagation of laser beams through atmospheric turbulence (Gaussian beams, Rytov theory, scintillation index, beam wander)
10. Modelling of free-space optical communication systems (aperture averaging, mean signal-to-noise ratio, false-alarm rate and fade probability, bit error-rate)
Module grade calculation
The module grade is the grade of the oral exam.

Workload
total 90 h, hereof 30 h contact hours and 60 h homework and self-studies

Recommendation
Basic knowledge of statistics.

Literature
Michael C. Roggemann, Byron M. Welsh, Imaging through Turbulence, CRC Press
Module: Advanced Inorganic Materials [M-CHEMBIO-101901]

Responsible: Prof. Dr. Claus Feldmann
Organisation: KIT Department of Chemistry and Biosciences
Part of: Specialization - Photonic Materials and Devices
Specialization - Quantum Optics & Spectroscopy

Credits: 3
Grading scale: Grade to a tenth
Recurrence: Each summer term
Duration: 2 terms
Language: English
Level: 4
Version: 2

Mandatory
T-CHEMBIO-103591 Advanced Inorganic Materials 3 CR

Prerequisites
None

Competence Goal
The students refresh and elaborate their knowledge on inorganic materials, materials chemistry as well as basic inorganic chemistry and solid state chemistry. This comprises fundamental aspects of the chemistry of the elements as well as state-of-the-art knowledge on the synthesis, structure, properties (including optical properties) and application (including luminescence) of inorganic functional materials.

The students
• get familiar with basic inorganic chemistry and solid state chemistry
• get familiar with concepts of describing crystal structures
• know how to characterize inorganic solid compounds and materials
• learn how to prepare inorganic compounds and solid materials
• understand general aspects of structure-property relations
• comprehend general concepts of solid state chemistry and inorganic functional materials
• are able to rationalize fundamental properties of inorganic materials
know general trends in view of a technical application of advanced inorganic materials

Content
Selected aspects of modern functional inorganic materials, including:
• High-temperature ceramics and hard materials
• Color pigments – from Egyptian blue to 2D Bragg stacks
• Phosphors, luminescence, spectroscopy
• Fast ion conductors and high-power batteries
• Superconductors: metals, alloys, oxocuprates and current developments
• Porous networks: from zeolites to metalorganic frameworks (MOFs)
• Transparent conductive oxides and dye-sensitized solar cells
• Magnetic pigments: magnetic recording, superparamagnetism and magnetothermal therapy
• Modern thermoelectric materials
• Fullerenes and fibre-reinforced composite materials
• Nanomaterials: Quantum Dots, hollow spheres and nanotubes
. . . and other examples of advanced functional materials

Literature
Selected reviews (as given in the lecture).
2.3 Module: Advanced Molecular Cell Biology [M-CHEMBIO-101904]

**Responsible:** Prof. Dr. Martin Bastmeyer  
Dr. Franco Weth

**Organisation:** KIT Department of Chemistry and Biosciences

**Part of:** Specialization - Biomedical Photonics (Compulsory Modules)  
Additional Examinations

<table>
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<th>Level</th>
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<td>Each winter term</td>
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<td>4</td>
<td>3</td>
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**Mandatory**

| T-CHEMBIO-105196 | Advanced Molecular Cell Biology | 5 CR | Weth |

**Competence Certificate**
The exam will be oral or written depending on the number of course participants. The exact modality of the exam will be announced at the beginning of the semester. The exam is scheduled for the break after the WS. A resit exam will be offered when needed.

**Prerequisites**
none

**Competence Goal**
The students
- are able to extract the central ideas from an advanced textbook or review article and introduce their fellow student to the topic,
- have acquired an advanced knowledge of the cell division cycle and exemplify applications of FRET for its analysis,
- understand DNA replication, recombination and repair and the basis of fluorescence based deep sequencing,
- are familiar with nuclear organization and epigenetic regulation and FISH as a means of analysing chromosomes,
- understand protein folding and degradation and discuss optical tweezers as a tool for the investigation of the folding problem,
- can address posttranslational modifications and cutting edge technologies based on fluorophore click-chemistry to observe them,
- comprehend cell suicide (apoptosis) and techniques of laser ablation to induce cell death
- are familiar with the different forms of cell/cell and cell/matrix contacts and with TIRF microscopy as a means of studying them,
- conceive the mechanisms of cell migration and their observation by live cell imaging,
- are familiar with principal mechanisms of embryonic development and understand fluorescent microarray technology for profiling the accompanying gene expression changes,
- understand the concepts of tissues, stem cells and cancer and of the quantification of gene expression by fluorescent nanostring and real-time fluorescence spectroscopy (qPCR),
- understand excitability and synaptic transmission in neurons and their observation with voltage and calcium sensitive fluorophores,
- are acquainted with the concepts of immunity and the application of antibodies in fluorescent immunoassays.

**Content**
Progress in no other field of science is so intimately linked to the continuing development and welfare of humanity as the achievements of the life sciences. Modern biomedical research, however, is inconceivable without cutting-edge Optics & Photonics technologies ranging from high-throughput sequencing to super-resolution microscopy. Most students of Optics & Photonics are therefore likely to get in contact with life scientists during their careers. In this course, they will prepare themselves for fruitful future collaborations, which rely on shared concepts and terminologies. To this end, students will familiarize themselves with the basic principles and ideas of Molecular Cell Biology, which is at the heart of modern Biosciences.

I. Introduction to the cell  
II. Concepts from Organic Chemistry pertinent to the Life Sciences  
III. Concepts from Physical Chemistry pertinent to the Life Sciences  
IV. Nucleic acids and proteins  
V. Gene expression  
VI. Methods  
VII. Genomic variability and evolution  
VIII. Cell membranes  
IX. Energy metabolism  
X. Cell signalling  
XI. Cell compartments  
XII. Cytoskeleton and cell division

**Workload**
Total 150h, hereof 40h contact hours (30h class, 10h problem class), and 110h homework and self-studies
Recommendation
Passed exam of the Adjustment Course in "Basic Molecular Cell Biology".

Learning type
Advanced textbook or review articles will be announced on a weekly basis. They have to be read by all participants. The contents will be discussed in the class sessions. Each class session is chaired by one participant and all participants have to contribute a sub-chapter / figure per session. For the problems class, exercise sheets will be handed out and participants have to be prepared to present their solutions.

Literature
2.4 Module: Automotive Vision [M-MACH-102693]

**Responsible:** Dr. Martin Lauer  
Prof. Dr.-Ing. Christoph Stiller

**Organisation:** KIT Department of Mechanical Engineering

**Part of:** Specialization - Optical Systems  
Additional Examinations

<table>
<thead>
<tr>
<th>Credits</th>
<th>Grading scale</th>
<th>Recurrence</th>
<th>Duration</th>
<th>Language</th>
<th>Level</th>
<th>Version</th>
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</thead>
<tbody>
<tr>
<td>6</td>
<td>Grade to a tenth</td>
<td>Each summer term</td>
<td>1 term</td>
<td>English</td>
<td>4</td>
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</tr>
</tbody>
</table>

**Mandatory**

| T-MACH-105218 | Automotive Vision | 6 CR | Lauer, Stiller |

**Competence Certificate**

Type of Examination: written exam  
Duration of Examination: 60 minutes

**Prerequisites**

none

**Competence Goal**

After having participated in the lecture the participants have gained knowledge on modern techniques of signal processing and artificial intelligence which can be used to evaluate video sequences, to relate the image content to a spatial context and to interpret the content semantically. This comprises, binocular reconstruction, recognition of movements in video sequences, state space modeling and Bayesian filters, and the recognition of road surfaces and object behavior. The participants have learned to analyze the algorithms mathematically, to implement them in software, and to apply them to tasks in autonomous driving and mobile robots. The participants are able to analyze problems in the areas mentioned before and to develop appropriate solutions.

**Content**

Machine perception and interpretation of the environment forms the basis for the generation of intelligent behavior. Especially visual perception opens the door to novel automotive applications. Driver assistance systems already improve safety, comfort and efficiency in vehicles. Yet, several decades of research will be required to achieve an automated behavior with a performance equivalent to a human operator. The lecture addresses students in mechanical engineering and related subjects who intend to get an interdisciplinary knowledge in a state-of-the-art technical domain. Machine vision and advanced information processing techniques are presented to provide a broad overview on seeing vehicles. Application examples from cutting-edge and future driver assistance systems illustrate the discussed subjects. The lecture consists out of 2 hours/week of lecture and 1 hour/week of computer exercises. In the computer exercises methods introduced in the lecture will be implemented in MATLAB and tested experimentally.

**Workload**

180 hours  
comprised out of:

- hours of lecture: $15 \times 3 = 45$ h  
- preparation time prior to and after lecture: $15 \times 5 = 75$ h  
- exam preparation and exam: 60 h

**Learning type**

Lecture

**Literature**

TBA
Module: Basic Molecular Cell Biology [M-CHEMBIO-101903]

Responsible: Prof. Dr. Martin Bastmeyer, Dr. Franco Weth

Organisation: KIT Department of Chemistry and Biosciences

Part of: Adjustment Courses (mandatory)

Credits: 2
Grading scale: pass/fail
Recurrence: Each summer term
Duration: 1 term
Language: English
Level: 4
Version: 2

Mandatory
T-CHEMBIO-105199 Basic Molecular Cell Biology 2 CR Weth

Competence Certificate
The written exam over 120 Minutes is scheduled for the beginning of the break after the SS.

Prerequisites
none

Competence Goal
The students

- comprehend the fact that all life on earth is based on cells,
- understand the basic build-up of eukaryotic cells,
- know the central concepts of Organic and Physical Chemistry, on which life is based,
- know the structures and major functions of the four classes of biological macromolecules,
- comprehend the idea that a cell is a micro-factory based on nanomachines (proteins) that are instructed by informational macromolecules (DNA, RNA),
- conceive the idea that the variation of genomic information underlies evolution,
- know the methods of how cells acquire energy for life processes,
- are familiar with the roles of the cytoskeleton organelles and the cell membrane and
- are familiar with the basics of cellular responsivity towards external cues,
- get a first glimpse on key technologies, which underlie experimental progress in the field

Content
I. Introduction to the cell
II. Concepts from Organic Chemistry pertinent to the Life Sciences
III. Concepts from Physical Chemistry pertinent to the Life Sciences
IV. Nucleic acids and proteins
V. Gene expression
VI. Methods
VII. Genomic variability and evolution
VIII. Cell membranes
IX. Energy metabolism
X. Cell signalling
XI. Cell compartments
XII. Cytoskeleton and cell division

Workload
Working hours in total are 60 hours for an average student. Thereof 30 h (= approx. 14 x 2h) attendance in lectures and 30 h self-study as preparation for the exam.

Learning type
Progress in no other field of science is so intimately linked to the continuing development and welfare of humanity as the achievements of the life sciences. Modern biomedical research, however, is inconceivable without cutting-edge Optics & Photonics technologies ranging from high-throughput sequencing to super-resolution microscopy. Most students of Optics & Photonics are therefore likely to get in contact with life scientists during their careers. In this course, they will prepare themselves for fruitful future collaborations, which rely on shared concepts and terminologies. To this end, students will familiarize themselves with the basic principles and ideas of Molecular Cell Biology, which is at the heart of modern Biosciences.

Literature
Lecture presentations will be accessible in pdf-format.
Principles of Cell Biology, Plopper, G., Jones & Bartlett Publ., 2011

Optics and Photonics Master 20151 (Master of Science (M.Sc.))
Module Handbook as of 24/10/2022
Module: Business Innovation in Optics and Photonics [M-ETIT-101834]

Responsible: Prof. Dr. Werner Nahm
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Interdisciplinary Qualification

Credits: 4
Grading scale: Grade to a tenth
Recurrence: Each winter term
Duration: 1 term
Language: English
Level: 4
Version: 1

Mandatory
T-ETIT-104572 Business Innovation in Optics and Photonics 4 CR Nahm

Competence Certificate
Type of Examination: examination of another type
Duration of Examination: 4 group presentations à 20 minutes (approx.)
Modality of Exam: The exam consists of four group presentations. 2nd day: Technology Presentation. 3rd day: Development plan presentation. 4th day: Business Canvas presentation. Final presentation at Zeiss visit: Business pitch

Prerequisites
Good knowledge in optics & photonics.

Competence Goal
The student has an understanding how innovative concepts for optical and photonics products are transferred into a successful business development. The student knows about and makes first hands on experiences on business development aspects in a technology start up environment. The students acquire specialized knowledge in technologies and applications in the field of smart mobile solutions for optical applications as well as an introduction into the field of patent rights.

The students can organize themselves in groups and distribute and execute tasks. Further they gain competences in the fields teamwork, organization and communication.

The students
- understand the implications of intellectual property
- are able to perform data base research
- know how to develop a business plan
- get an understanding of how to design a project
- are able to develop in small groups innovative business cases for a potential future product

Content
This course is instructed and presented by external innovation specialists of the R&D, business and management departments of the Carl Zeiss AG.

- Introduction: Examples of existing smart mobile device applications, Brainstorming for ideas
- Technology Introduction: Mobile device technology, Optic components, Display technology (LCD, OLED), Tracking and Sensor Technologies in smart mobile devices
- Group Work Technology
- Group Presentations Technology
- Business Case Development/ Business Plan: Market segmentation, Market research, Essentials of finance, How to write a business plan?
- Project Design: How to run an agile R&D Project?, Traget costing, Networked product development
- Agile project simulation
- Group Work
- Excursion to Carl Zeiss AG in Oberkochen (full day)
- Presentation of results of the group work to the new business experts committee of the Carl Zeiss AG

Module grade calculation
The final grade is the weighted average of the gradings for the four presentations. The three intermediate presentations are each weighted 1, the final presentation is weighted 3.

Workload
total 120 h, thereof 34 h contact hours and 86 h preparation, homework, self-studies and excursion
2.7 Module: Computational Photonics, without ext. Exercises [M-PHYS-103089]

**Responsible:** Prof. Dr. Carsten Rockstuhl  
**Organisation:** KIT Department of Physics  
**Part of:**  
- Specialization - Photonic Materials and Devices  
- Specialization - Optical Systems  
- Specialization - Solar Energy (Compulsory Elective Modules)  
**Additional Examinations**

<table>
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**Mandatory**

| T-PHYS-106131 | Computational Photonics, without ext. Exercises | 6 CR | Rockstuhl |

**Competence Certificate**  
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

**Prerequisites**  
none

**Competence Goal**  
The students can use a computer to solve optical problems and can use a computer to visualize details of the light matter interaction, know different strategies to solve Maxwell’s equations on rigorous grounds, know how spatial symmetries and the arrangement of matter in space can be used to formulate Maxwell’s equations such that they are amenable for a numerical solution, can implement programs with a reasonable complexity by themselves, can use a computer to discuss and explore optical phenomena, and are familiar with basic computational strategies that emerge in photonics, but comparably in any other scientific discipline as well.

**Content**

- Transfer Matrix Method to describe the optical response from stratified media  
- Finite Differences to characterize eigenmode in fiber waveguides  
- Beam propagation method to describe the evolution of light in the realm of integrated optics  
- Grating methods to predict reflection and transmission from periodically arranged material in 1D and 2D  
- Mie Theory to describe the scattering of light from individual cylindrical or spherical objects  
- Finite-Difference Time-Domain method as a general purpose tool to solve micro- and nanooptical problems  
- Multiple Multipole Method as an approach to describe light scattering from single objects with an arbitrary shape  
- Greens’ Methods to discuss equally the scattering from single objects but embedded in an inhomogeneous background  
- Boundary Integral Method to discuss scattering from objects highly efficient using expressions for the fields on the surface

**Recommendation**  
Interest in theoretical physics, optics and electrodynamics. Moreover, interest in computational aspects is important.

**Literature**

- "Classical Electrodynamics" John David Jackson  
- "Theoretical Optics: An Introduction" Hartmann Römer  
- "Principles of Optics" M. Born and E. Wolf  
- "Light Scattering by Small Particles" H. C. van de Hulst

Specific references for the individual topics will be given during the lectures. The lecture material that will be fully made available online.
2.8 Module: Digital Signal Processing in Optical Communications – with Practical Exercises [M-ETIT-103450]

Responsibility: Prof. Dr.-Ing. Sebastian Randel
Organization: KIT Department of Electrical Engineering and Information Technology
Part of: Specialization - Optical Systems

Additional Examinations

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<tr>
<th>Credits</th>
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Mandatory

T-ETIT-106852 Digital Signal Processing in Optical Communications – with Practical Exercises 6 CR Randel

Competence Certificate
The exercise sheets and the oral questionnaire are used to rate other types of examinations. The overall impression is assessed. Duration about 20 minutes.

Prerequisites
Basic knowledge of optical communication systems. Proven, for example, by completing one of the modules "Optical Networks and Systems-ONS", "Optoelectronic Components -OC, or" Optical Transmitters and Receivers - OTR.

Competence Goal
- The students understand the functioning of modern optical communication systems, which combine electro-optical technologies with digital signal processing.
- You are able to independently implement and test algorithms from digital signal processing as well as suitable simulation and test environments in a suitable scripting language (e.g. Matlab or Python).
- Furthermore, they can estimate the influence of interfering effects occurring in the glass fiber such as chromatic dispersion and polarization mode dispersion.
- You are also able to estimate the complexity and power consumption of the resulting logic circuits.

Content
- The module deals with algorithms from digital signal processing that are used in broadband optical communication systems. Practical exercises in which the students implement algorithms independently form an essential part of the module.
- In lectures there will be an introduction to the development of digital coherent transmitters and receivers. Building on this, essential function blocks such as the dispersion compensation, the adaptive equalization of polarization mode dispersion as well as carrier and clock recovery are discussed.
- In the exercises, these function blocks are to be implemented in software (Matlab, Octave).
- In addition, individual examples show how digital signal processing algorithms are described in hardware (Hardware Description Language - HDL) and how their complexity scales.

Module grade calculation
The exercise sheets and the oral questioning are used to rate other types of examinations. The overall impression is assessed.

Workload
Approximately 170h workload of the student. The workload includes:
- 30h - attendance in lectures
- 30h - exercises
- 70h - preparation / follow-up
- 40h - written exercises and exam

Recommendation
Knowledge of the basics of optical communication technology and digital signal processing is helpful.
2.9 Module: Electric Power Generation and Power Grid [M-ETIT-101917]

**Responsible:** Dr.-Ing. Bernd Hoferer  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** Specialization - Solar Energy (Compulsory Elective Modules)  
**Additional Examinations**

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<tr>
<th>Credits</th>
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<th>Duration</th>
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<td>Each winter term</td>
<td>1 term</td>
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Mandatory

| T-ETIT-103608 | Electric Power Generation and Power Grid | 3 CR | Hoferer |

**Competence Certificate**

Type of Examination: oral exam  
Duration of Examination: approx. 20 minutes

**Prerequisites**

Anyone who has completed the Electrical Power Generation (EEE) module in the Bachelor (SPO 2015 and 2018) should Master does not select the Electric Power Generation and Power Grid module.

**Competence Goal**

The students

- are familiar with characteristics of different types of power generation  
- are able to evaluate the performance of different types of power generation  
- comprehend the challenges in power transmission systems due to volatile power generation.  
- can derive solutions for a future power generation pool and power grid  
- are able to calculate the efficiency factor of power generation systems  
- know how to apply mathematical concepts like load flow calculation and short-circuit calculations

**Content**

I. Energy resources and energy consumption  
II. Conversion of primary energy in power plants; thermo-dynamical fundamental terms, processes in steam power plants; steam power plants components; flue gas cleaning  
III. Synchronous machines  
IV. Thermal power plants (fossil-fueled steam generation, nuclear-fueled steam generation)  
V. Renewable energy generation (hydro-electric, wind, solar)  
VI. Transmission systems (AC power transmission, DC power transmission)  
VII. Load flow calculations

**Module grade calculation**

The module grade is the grade of the oral exam.

**Workload**

total 90 h, hereof 30 h contact hours and 60 h homework and self-studies

**Literature**

Schwab; Electric energy systems;  
Fink, Beaty; Standard handbook for electrical engineers
2.10 Module: Electromagnetics and Numerical Calculation of Fields [M-ETIT-100386]

**Responsible:** Prof. Dr.-Ing. Thomas Zwick  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** Engineering Optics & Photonics

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<td>Each winter term</td>
<td>1 term</td>
<td>English</td>
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</table>

**Mandatory**

| T-ETIT-100640 | Electromagnetics and Numerical Calculation of Fields | 4 CR | Zwick |

**Competence Certificate**

Success control is carried out in the form of a written test of 120 minutes.

**Prerequisites**

none

**Competence Goal**

Students with very different background in electromagnetic field theory will be brought to a high level of comprehension. They will understand the concept of electric & magnetic fields and of electric potential & vector potential and they will be able to solve simple problems of electric & magnetic fields using mathematics. They will understand the equations and solutions of wave creation and wave propagation. Finally the student will have learnt the basics of numerical field calculation and be able to use software packages of numerical field calculation in a comprehensive and critical way.

The student will

- be able to deal with all quantities of electromagnetic field theory (E, D, B, H, J, M, P, ...), in particular: how to calculate and how to measure them,
- derive various equations from the Maxwell equations to solve simple field problems (electrostatics, magnetostatics, steady currents, electromagnetics),
- be able to deal with the concept of field energy density and solve practical problems using it (coefficients of capacitance and coefficients of inductance),
- be able to derive and use the wave equation, in particular: to solve problems how to create a wave and calculate solutions of wave propagation through various media,
- be able to outline the concepts, the main application areas and the limitations of methods of numerical field calculation (FDM, FDTD, FIM, FEM, BEM, MoM, TLM)
- be able to use one exemplary software package of numerical field calculation and solve simple practical problems with it.
Content
This course first gives a comprehensive recap of Maxwell equations and important equations of electromagnetic field theory. In the second part the most important methods of numerical field calculation are introduced.

Maxwell’s equations, materials equations, boundary conditions, fields in ferroelectric and ferromagnetic materials
electric potentials, electric dipole, Coulomb integral, Laplace and Poisson’s equation, separation of variables in cartesian, cylindrical and spherical coordinates
Dirichlet Problem, Neumann Problem, Greens function, Field energy density and Poynting vector,
electrostatic field energy, coefficients of capacitance, vector potential, Coulomb gauge, Blot-Savart-law, magnetic field energy, coefficients of inductance magnetic flux and coefficients of mutual inductance, field problems in steady electric currents,

law of induction, displacement current
general wave equation for E and H, Helmholtz equation

skin effect, penetration depth, eddy currents

retarded potentials, Coulomb integral with retarded potentials
wave equation for potential and Vector potential and A, Lorentz gauge, plane waves
Hertzian dipole, near field solution, far field solution

transmission lines, fields in coaxial transmission lines

waveguides, TM-waves, TE-waves

finite difference method FDM
finite difference - time domain FDTD, Yee ’s algorithm
finite difference - frequency domain

finite integration method FIM
finite element method FEM
boundary element method BEM, Method of Moments (MOM), Transmission Line Matrix Methal (TLM),
solving large systems of linear equations

basic rules for good numerical field calculation

The lecturer reserves the right to alter the contents of the course without prior notification.

Module grade calculation
The module grade is the grade of the written exam.

Workload
Each credit point corresponds to approximately 25-30 hours of work (of the student). This is based on the average student who achieves an average performance. The workload includes:

Attendance time in lectures (3 h 15 appointments each) = 45 h

Self-study (4 h 15 appointments each) = 60 h

Preparation / post-processing = 20 h

Total effort approx. 125 hours = 4 LP

Recommendation
Fundamentals of electromagnetic field theory.

Literature
Matthew Sadiku (2001), Numerical Techniques in Electromagnetics. CRC Press, Boca Raton, 0-8493-1395-3


Module: Fabrication and Characterisation of Optoelectronic Devices [M-ETIT-101919]

**Responsible:** Prof. Dr. Bryce Sydney Richards  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** Advanced Optics & Photonics – Methods and Components

<table>
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<th>Credits</th>
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<td>Each summer term</td>
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</table>

**Mandatory**

| T-ETIT-103613 | Fabrication and Characterisation of Optoelectronic Devices | 3 CR | Richards |

**Competence Certificate**

Type of Examination: written exam  
Duration of Examination: 120 Minutes  
Modality of Exam: One written exam offered at the end of each semester.

**Prerequisites**

None

**Competence Goal**

The students build knowledge on process technology for the fabrication of a range of optoelectronic devices, including LEDs, solar cells, laser diodes, photodiodes, etc. They learn to compare the advantages of different technological approaches, including their economic boundary conditions. This is a technological-based course where students will use their prior fundamental knowledge to gain a firm grasp on the fabrication sequences and characterisation (optical, electrical, electronic, materials) steps that are required to realise the above devices.

While fulfilling the learning targets, the students

- possess the basic knowledge about the working principles of optoelectronic devices;
- comprehend the boundary conditions for the design of optoelectronic devices and have a good understanding of the challenges in microfabrication
- are familiar with different lithographic techniques, including e-beam lithography, optical lithography, multiple-photon lithography, X-ray lithography, etc.
- comprehend the different techniques that are available for thin-film deposition of dielectrics, metals and semiconductors
- understand what role micro-optics can play in such devices
- be able to determine the most promising characterisation techniques for evaluating material quality, electronic properties, as well as optical and electrical performance.
- Exposure to different dry- and wet-etching processes to help realise device structures
- have an understanding of the economic implications of the chosen technologies and their compatibility with highthroughput production
Content
I. Overview: Opto-electronic Devices
II. Thin-film growth and deposition
   • epitaxial growth of III-V semiconductors, as well as Si and Ge
   • chemical vapour deposition (CVD) based processes, including atomic layer deposition (ALD)
   • physical vapour deposition (PVD) based processes, including evaporation (thermal and e-beam) and sputtering (DC and RF)

III. Lithographic techniques
   • e-beam lithography, optical lithography, laser interference lithography, two-photon lithography, X-ray lithography

IV. Etching processes
   • wet- and dry-etching processes for semiconductors, dielectrics and metals

V. Micro-optics
   • micro-optic design in opto-electronic devices

VI. Characterisation:
   • materials properties (electron microscopy, crystallinity, bonding energies, elemental concentrations, layer thicknesses ...)
   • electronic properties (dopant profiling, mobility, minority carrier lifetimes, resistivity, bandgap measurements, ...)
   • optical (spectrophotometry, photoluminescence, ...)
   • electrical (current-voltage measurements, quantum efficiency / spectral response, ...)

VII. Excursion (TBA)

Module grade calculation
The module grade is the grade of the written exam.

Workload
Total 90h, hereof 30h contact hours (24h lecture, 6h problem class), and 60h homework and selfstudies

Literature
TBD
2.12 Module: Field Propagation and Coherence [M-ETIT-100566]

Responsible: Prof. Dr. Wolfgang Freude
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Specialization - Photonic Materials and Devices
Specialization - Optical Systems
Additional Examinations

<table>
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<th>Credits</th>
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<th>Recurrence</th>
<th>Duration</th>
<th>Language</th>
<th>Level</th>
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</table>

Mandatory

| T-ETIT-100976 | Field Propagation and Coherence | 4 CR | Freude |

Competence Certificate
Type of Examination: oral exam
Duration of Examination: approx. 30 minutes
Modality of Exam: Oral examination, usually one examination day per month during the summer and winter terms. An extra questions-and-answers session will be held for preparation if students wish so.

Prerequisites
none

Competence Goal
Presenting in a unified approach the common background of various problems and questions arising in general optics and optical communications
The students

- know the common properties of counting of modes, density of states and the sampling theorem
- comprehend the relationship between propagation in multimode waveguides, mode coupling, MMI and speckles
- can analyze propagation in homogeneous media with respect to system theory, antennas, and the resolution limit of optical instruments
- understand that coherence as a general concept comprises coherence in time, in space and in polarisation
- comprehend the implication of complete spatial incoherence, and what is the radiation efficiency of a source with a diameter smaller than a wavelength (the mathematical Hertzian dipole, for instance)
- can assess when can two incandescent bulbs form an interference pattern in time
- know under which conditions a heterodyne radio receiver, which is based on a non-stationary interference, actually works

Content
The following selection of topics will be presented:

- Light waves, modes and rays: Longitudinal and transverse modes, sampling theorem, counting and density of modes ("states")
- Propagation in homogeneous media: Resolution limit. Non-paricial and paricial optics. Gaussian beam. ABCD matrix

Module grade calculation
The module grade is the grade of the oral exam.

Workload
total 120 h, hereof 45 h contact hours (30 h lecture, 15 h problem class), and 75 h homework and self-studies

Recommendation
Minimal background required: Calculus, differential equations and Fourier transform theory. Electrodynamics and field calculations or a similar course on electrodynamics or optics is recommended.
Literature
Detailed lecture notes as well as the presentation slides can be downloaded from the IPQ lecture pages. Additional reading:
Hecht, E.: Optics, 2. Ed. Reading: Addison-Wesley 1974
Further textbooks in German (also in electronic form) can be named on request
2.13 Module: Fundamentals of Optics and Photonics [M-PHYS-101927]

**Responsible:** Prof. Dr. David Hunger  
**Organisation:** KIT Department of Physics  
**Part of:** Physical Optics & Photonics

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**Mandatory**

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<td>Fundamentals of Optics and Photonics - Unit</td>
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<td>T-PHYS-103628</td>
<td>Fundamentals of Optics and Photonics</td>
<td>8 CR</td>
<td>Hunger</td>
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</table>

**Competence Certificate**

Written exam, duration 120 minutes  
The written exam is scheduled for the beginning of the break after the WS. A resit exam is offered at the end of the break. A test exam is offered before the Christmas holidays.

**Prerequisites**

One exercise sheet is handed out to the students as homework each week. Solutions of the problems have to be submitted.

**Competence Goal**

The students from different backgrounds refresh and elaborate their knowledge of basic optics and photonics. They comprehend the physics of optical phenomena and their application in simple optical components. They learn how to describe physical laws in a mathematical form and how to verify these laws in experiments, i.e., they acquire scientific methodology. They train to solve problems in basic and applied optics & photonics by mathematical evaluation of physical laws.

The students

- can derive the description of basic optical phenomena from the ray, wave or particle properties of light
- know how to calculate ray paths using matrix optics and how to apply the laws of beam optics
- understand the implications of anisotropic media to the polarization of light and related device application
- comprehend the concepts of coherence, interference and diffraction and are aware of their importance in optics and photonics
- are able to design and evaluate the performance of interference/diffraction based optical devices like interferometers, optical coatings, spectrometers and holograms
- know how to apply mathematical concepts like correlation functions and Fourier transformation to the solution of optical problems
- are familiar with basic microscopic models of light-matter interaction and are able to apply these concepts to describe phenomena like light propagation, frequency-dependence of optical constants, absorption and emission
- conceive the operation principle of various types of lasers
- have a good visualization of numerous optical phenomena acquired from the demonstration experiments
- they understand how scientific research advances by the interplay of experimental findings, phenomenological description and mathematical treatment

**Content**

I. Introduction (Ray Optics; Wave Optics; Photons)  
II. Beam Optics (Gaussian Modes, Effect of Optical Components on Gaussian Beams)  
III. Polarization and Optical Anisotropy (Polarization, Jones Vectors and Matrices; Birefringence and its Applications; Optical Activity; Induced Anisotropy and Modulators)  
IV. Coherence, Interference and Diffraction (Spatial and Temporal Coherence, Fourier Transformation, Correlation Functions, Interference; Interferometer; Fourier Spectroscopy; Multi-Beam Interference, Fabry-Perot, Dielectric and Bragg Mirrors; Diffraction at Slit, Aperture and Grating; Fresnel and Fraunhofer Diffraction; Fourier Optics; Diffraction-Limited Resolution; Spectrometer; Diffractive Optics, Holography)  
V. Light and Matter (Lorentz Oscillator Model, Dielectric Function, Polariton Propagation; Kramers-Kronig Relations; Two-Level Systems, Einstein Coefficients, Fermi’s Golden Rule)  
VI. Laser: Basic Principles (Components of a Laser, Types of Lasers; Short-Pulse Generation)

**Workload**

total 240 h, hereof 90h contact hours (60h lecture, 30h problem class), and 150h homework and self-studies

**Recommendation**

Solid mathematical background, basic knowledge in physics
Learning type
Lecture (including demonstration experiments) and problem class

Literature
D. Meschede: Optics, Light and Lasers
B.E.A. Saleh, M.C. Teich: Fundamentals of Photonics
F.G. Smith, T.A. King and D. Wilkins: Optics and Photonics, An Introduction
### 2.14 Module: Further Examinations [M-ETIT-102000]

**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** Additional Examinations

<table>
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<th>Credits</th>
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<th>Level</th>
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</table>
Responsible: Katrina Pangritz
Organisation:
Part of: Interdisciplinary Qualification
  Additional Examinations

Credits 4  Grading scale Grade to a tenth  Recurrence Each winter term  Duration 1 term  Language German  Level 4  Version 4

Mandatory
T-IDSCHOOLS-109427 German at ID A1.1  4 CR Pangritz

Competence Certificate
The results will be assessed in the form of a 90-minute written examination pursuant to § 4 Para. 2 No. 1 SPO Master "Optics & Photonics". The module mark is the mark of the written examination.

Prerequisites
In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester
2. passing 2 out of 3 tests written during the semester as a performance test
3. submission of 2 out of 3 written homework assignments (texts) during the semester

Competence Goal
Participants are able to understand and use familiar everyday expressions and very basic phrases aimed at satisfying concrete needs. They can introduce themselves and others and ask other people questions about personal details – e.g. where they live, people they know or things they have – and answer questions of this kind. They can communicate in a simple way provided the other person speaks slowly and clearly and is prepared to help.

Content
In addition to the linguistic actions already mentioned in the "Competence Goals", it is also a matter of teaching grammatical skills, namely the conjugation of verbs in German in Präsens and Perfekt tense, regular and irregular verbs, verbs with vowel changes, nouns, prepositions bei, als, in and aus, negation nicht, numbers, word order in main clauses, ja-nein-doch, possessive pronouns, definite articles der / die / das, indefinite articles ein / eine and plural in nominative and accusative, negative articles kein, keine, modal verb können.

Treated word fields: Countries, alphabet, profession, family, family status, numbers 1-1000000, languages, furniture, colors, materials, office, computer, times of day, weekdays, months, seasons, food, transportation, travel, leisure activities, everyday activities.

Module grade calculation
The module mark corresponds to 100 % of the mark of the written examination at the end of the semester.

Workload
A total of about 120 hours, composed of:

1. attendance time in the language course (approx. 60 SWS)
2. preparation/post-processing of the above (approx. 60 hours)
3. exam preparation and attendance of the above (approx. 15 hours)

Recommendation
Strong motivation for self-study
### 2.16 Module: German at ID A1.2 [M-IDSCHOOLS-104604]

**Responsible:** Katrina Pangritz  
**Organisation:**  
Part of: Interdisciplinary Qualification  
Additional Examinations

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<th>Credits</th>
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</table>

**Competence Certificate**  
The results will be assessed in the form of a 90-minute written examination pursuant to § 4 Para. 2 No. 1 SPO Master "Optics & Photonics".

The module mark is the mark of the written examination.

**Prerequisites**  
Successful completion of German level A1.1

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester  
2. passing 2 out of 3 tests written during the semester as a performance test  
3. submission of 2 out of 3 written homework assignments (texts) during the semester

**Competence Goal**  
Participants are able to understand and use familiar everyday expressions and very basic phrases aimed at satisfying concrete needs. They can introduce themselves and others and ask other people questions about personal details – e.g. where they live, people they know or things they have – and answer questions of this kind. They can communicate in a simple way provided the other person speaks slowly and clearly and is prepared to help.

**Content**  
In addition to the linguistic actions already mentioned in the "Competence Goals", it is also a matter of teaching grammatical skills, namely local prepositions with dative, genitive for proper names, possessive article sein / ihr, verbs in dative, personal pronouns in accusative and dative, temporal prepositions vor, nach, in, für, prepositions mit / ohne, modal verbs dürfen, müssen, wollen, sollen, imperative Sie / du / ihr, Präteritum tense war / hatte, Perfekt tense in inseparable verbs, prefix un-, suffix -los, comparisons, conjunction denn, subjunctive II würde, ordinals.

Treated word fields: Institutions and places in the city, apartments and houses, in hotels, plans and wishes, body parts, appearance, character, household activities, rules in traffic and environment, clothing, weather, cardinal points and festivals.

**Module grade calculation**  
The module mark corresponds to 100 % of the mark of the written examination at the end of the semester.

**Workload**  
A total of about 120 hours, composed of:

1. attendance time in the language course (approx. 60 SWS)  
2. preparation/post-processing of the above (approx. 60 hours)  
3. exam preparation and attendance of the above (approx. 15 hours)

**Recommendation**  
Strong motivation for self-study
2.17 Module: German at ID A2.1 [M-IDSCHOOLS-102357]

Responsible: Katrina Pangritz
Organisation:
Part of: Interdisciplinary Qualification
Additional Examinations

<table>
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Mandatory

T-IDSCHOOLS-112581 German at ID A2.1 4 CR Pangritz

Competence Certificate

The results of the module will be assessed in the form of a 90-minute written examination and a presentation (examination of another type) pursuant to § 4 Para. 2 No. 1 and No. 3, SPO Master "Optics & Photonics".

Prerequisites

Successful completion of German level A1.2 or German A1

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester
2. passing 2 out of 3 tests written during the semester as a performance test
3. submission of 2 out of 3 written homework assignments (texts) during the semester
4. presentation

Competence Goal

Participants will be able to understand sentences and frequently used expressions related to areas of most immediate relevance (e.g. very basic personal and family information, shopping, employment, local environment). They can communicate in simple, routine situations requiring a simple and direct exchange of information on familiar and routine matters. They can describe in simple terms aspects of their own background and education, the immediate environment and matters related to immediate needs.

Content

In addition to the linguistic actions already mentioned in the "Competence Goals", it is also a matter of conveying grammatical skills, namely subjunctive II, reflexive verbs, Perfekt tense with haben and sein, suffixes -er and -ung, adjective declension, possessive articles, prepositions with accusative and dative, temporal prepositions and adverbs, conjunctions weil, deshalb, wenn and dass.

Module grade calculation

The module grade consists of 75 % of the written examination at the end of the semester and 25 % of a presentation. The written examination lasts 90 minutes and includes all the skills practiced during the semester, namely listening and reading comprehension, writing and grammar.

The presentation should take approx. 5 minutes. In the presentation a prespecified topic from a familiar field is to be introduced to the audience, based on personal experience and by describing advantages and disadvantages of the matter, concluding with a well-founded statement of the student's own opinion. A handout should be prepared, including a list of expressions used in the presentation. The preparation of a PowerPoint presentation is optional.

The grade of the presentation is based on the evaluation of the following criteria and results in a total of max. 100 points:

- The chosen content (max. 20 points)
- The used language (max. 40 points)
- The execution (max. 40 points)

These three criteria are subdivided as follows:

The evaluation of the content is divided into (a total of 20 points): The adequacy of the selected content (up to a maximum of 10 points) and a meaningful structure of the presentation, reflected in the use of media and aid, including timely submission of the handout (up to a maximum of 10 points)

The evaluation of the language consists of (a total of 40 points): the correct use of grammar (up to a maximum of 20 points), the vocabulary used (up to a maximum of 10 points) and the use of structuring phrases (up to a maximum of 10 points).

The evaluation of the execution is made up of (a total of 40 points): the use of free and fluent speech (up to a maximum of 15 points), the pronunciation (up to a maximum of 5 points), the listener reference (up to a maximum of 5 points) and the interaction during the concluding discussion (up to a maximum of 15 points).
Workload
A total of about 120 hours, composed of:

1. attendance time in the language course (approx. 60 SWS)
2. preparation/post-processing of the above (approx. 60 hours)
3. exam preparation and attendance of the above (approx. 15 hours)

Recommendation
Strong motivation for self-study
2.18 Module: German at ID A2.2 [M-IDSCHOOLS-104605]

Responsible: Katrina Pangritz

Organisation:
Part of: Interdisciplinary Qualification
   Additional Examinations

<table>
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Mandatory

| T-IDSCHOOLS-112587 | German at ID A2.2 | 4 CR | Pangritz |

Competence Certificate
The results of the module will be assessed in the form of a 90-minute written examination and a presentation (examination of another type) pursuant to § 4 Para. 2 No. 1 and No. 3, SPO Master “Optics & Photonics”.

Prerequisites
Successful completion of German level A2.1

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester
2. passing 2 out of 3 tests written during the semester as a performance test
3. submission of 2 out of 3 written homework assignments (texts) during the semester
4. presentation

Competence Goal
Participants will be able to understand sentences and frequently used expressions related to areas of most immediate relevance (e.g. very basic personal and family information, shopping, employment, local environment). They can communicate in simple, routine situations requiring a simple and direct exchange of information on familiar and routine matters. They can describe in simple terms aspects of their own background and education, the immediate environment and matters related to immediate needs.

Participants can talk about media, travel, traffic, the weather, press and books, cultural events, mobility, other countries, education, internships, and schools.

Content
In addition to the linguistic actions already mentioned in the "Competence Goals", it is also a matter of conveying grammatical skills, namely question words, demonstrative articles, passive voice in Präsens tense, verbs with preposition, modal verbs in Präteritum tense, Präteritum tense, local prepositions gegenüber... von, an... vorbei and durch, conjunctions bis and seit, indirect questions, position of objects in the sentence, question and prepositional adverbs.

Module grade calculation
The module grade consists of 75 % of the written examination at the end of the semester and 25 % of a presentation. The examination lasts 90 minutes and includes all the skills practiced during the semester, namely listening and reading comprehension, writing and grammar.

The presentation, in which a German celebrity or a German Federal state is to be introduced to the audience, should take approx. 5-10 minutes. A handout should be prepared, including a list of expressions used in the presentation. The preparation of a PowerPoint presentation is optional.

The grade of the presentation is based on the evaluation of the following criteria and results in a total of max. 100 points:

- The chosen content (max. 20 points)
- The used language (max. 40 points)
- The execution (max. 40 points)

These three criteria are subdivided as follows:

The evaluation of the content is divided into (a total of 20 points): The adequacy of the selected content (up to a maximum of 10 points) and a meaningful structure of the presentation, reflected in the use of media and aid, including timely submission of the handout (up to a maximum of 10 points).

The evaluation of the language consists of (a total of 40 points): the correct use of grammar (up to a maximum of 20 points), the vocabulary used (up to a maximum of 10 points) and the use of structuring phrases (up to a maximum of 10 points).

The evaluation of the execution is made up of (a total of 40 points): the free and fluent speech (up to a maximum of 15 points), the pronunciation (up to a maximum of 5 points), the listener reference (up to a maximum of 5 points) and the interaction during the concluding discussion (up to a maximum of 15 points).
**Recommendation**
Strong motivation for self-study

**Base for**
A total of about 120 hours, composed of:

1. attendance time in the language course (approx. 60 SWS)
2. preparation/post-processing of the above (approx. 60 hours)
3. exam preparation and attendance of the above (approx. 15 hours)
2.19 Module: German at ID B1.1 [M-IDSCHOOLS-102359]

**Responsible:** Katrina Pangritz

**Organisation:**
- Part of: Interdisciplinary Qualification
- Additional Examinations

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<tr>
<td></td>
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**Mandatory**

T-IDSCHOOLS-110691 | German at ID B1.1 - written examination | 4 CR | Pangritz

**Competence Certificate**
The results of the module will be assessed in the form of a 120-minute written examination and a presentation (examination of another type) pursuant to § 4 Para. 2 No. 1 and No. 3, SPO Master "Optics & Photonics".

**Prerequisites**
Successful completion of German level A2.2 or German A2

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester
2. passing 2 out of 3 tests written during the semester as a performance test
3. submission of 2 out of 3 written homework assignments (texts) during the semester
4. presentation

**Competence Goal**
Participants can understand the main points when clear standard language is used and when it comes to familiar matters regularly encountered in work, school, leisure, etc. They can cope with most situations likely to arise when travelling in the area where the language is spoken. They can express themselves simply and coherently on topics which are familiar or of personal interest. They can describe experiences and events, dreams, hopes and ambitions and briefly give reasons or explanations for opinions and plans.

Participants can talk about character traits, work, housing, media and technology, invitations to dinner, customer service, animals, strengths and weaknesses, everyday mishaps and moments of happiness, health, sports and nutrition, and company events.

**Content**
In addition to the linguistic actions already mentioned in the "Competence Goals", it also a matter of teaching of grammatical skills, namely adjectives as nouns, n-declension, Präteritum tense, relative clauses with dative and prepositions, conjunctions obwohl, trotzdem, falls, da, während, bevor, nachdem, Futur I tense, infinitive with zu, adjective declension with comparative and superlative, subjunctive II past, Plusquamperfekt tense with haben and sein, genitive, adjective declension genitive, preposition trotz.
Module grade calculation
The module grade consists of 75% of the written examination at the end of the semester and 25% of a presentation. The examination lasts 120 minutes and includes all the skills practiced during the semester, namely listening and reading comprehension, writing and grammar.

The presentation, in which a German festival is to be introduced to the audience, should take approx. 10 minutes. A handout should be prepared, including a list of expressions used in the presentation. The preparation of a PowerPoint presentation is optional.

The grade of the presentation is based on the evaluation of the following criteria and results in a total of max. 100 points:
- The chosen content (max. 20 points)
- The used language (max. 40 points)
- The execution (max. 40 points)

These three criteria are subdivided as follows:
The evaluation of the content is divided into (a total of 20 points): The adequacy of the selected content (up to a maximum of 10 points) and a meaningful structure of the presentation, reflected in the use of media and aid, including timely submission of the handout (up to a maximum of 10 points).

The evaluation of the language consists of (a total of 40 points): the correct use of grammar (up to a maximum of 20 points), the vocabulary used (up to a maximum of 10 points) and the use of structuring phrases (up to a maximum of 10 points).

The evaluation of the execution is made up of (a total of 40 points): the free and fluent speech (up to a maximum of 15 points), the pronunciation (up to a maximum of 5 points), the listener reference (up to a maximum of 5 points) and the interaction during the concluding discussion (up to a maximum of 15 points).

Workload
A total of about 120 hours, composed of:
1. attendance time in the language course (approx. 60 SWS)
2. preparation/post-processing of the above (approx. 60 hours)
3. exam preparation and attendance of the above (approx. 15 hours)

Recommendation
Strong motivation for self-study
Responsible:  Katrina Pangritz
Organisation:  
Part of:  Interdisciplinary Qualification Additional Examinations

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<th>Credits</th>
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<th>Language</th>
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Mandatory
T-IDSCHOOLS-110699  German at ID B1.2 - written examination  4 CR  Pangritz

Competence Certificate
The results of the module will be assessed in the form of a 120-minute written examination and a presentation (examination of another type) pursuant to § 4 Para. 2 No. 1 and No. 3, SPO Master "Optics & Photonics".

Prerequisites
Successful completion of German level B1.1

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester
2. passing 2 out of 3 tests written during the semester as a performance test
3. submission of 2 out of 3 written homework assignments (texts) during the semester
4. presentation

Competence Goal
Participants can understand the main points when clear standard language is used and when it comes to familiar matters regularly encountered in work, school, leisure, etc. They can cope with most situations likely to arise when travelling in the area where the language is spoken. They can express themselves simply and coherently on topics which are familiar or of personal interest. They can describe experiences and events, dreams, hopes and ambitions and briefly give reasons or explanations for opinions and plans.

Participants can comment on topics of language, further education, application, memory and relationship, art and painting, politics and society, landscape and tourism, concerts and events, history, environment and climate, and visions of the future.

Content
In addition to the linguistic actions already mentioned in the "Competence Goals", it is also a matter of conveying grammatical skills, namely conjunctions and adverbs darum, deswegen, daher, aus diesem Grund, nämlich, preposition wegen, present and perfect participle as adjectives, two-part conjunctions nicht nur... sondern auch, sowohl... als auch, entweder... oder, weder... noch, zwar... aber, je... desto / umso, nicht / nur brauchen + infinitive with zu, expressions with es, modal particles denn, doch, eigentlich, ja, conjunctions indem, sodass, (an)statt / ohne... zu, (an)statt / ohne dass, damit, um... zu, als ob, local and temporal prepositions innerhalb, außerhalb, um... herum, an / am... entlang, passive voice in Präsens tense with modal verbs, passive voice in Perfekt and Präteritum tense.
Module grade calculation
The module grade consists of 75% of the written examination at the end of the semester and 25% of a presentation. The examination lasts 120 minutes and includes all the skills practiced during the semester, namely listening and reading comprehension, writing and grammar.

The presentation, in which a topic recently discussed the home media (media of the participant's home country) is to be introduced to the audience, should take approx. 10-15 minutes. A handout should be prepared, including a list of expressions used in the presentation. The preparation of a PowerPoint presentation is optional.

The grade of the presentation is based on the evaluation of the following criteria and results in a total of max. 100 points:
- The chosen content (max. 20 points)
- The used language (max. 40 points)
- The execution (max. 40 points)

These three criteria are subdivided as follows:

The evaluation of the content is divided into (a total of 20 points): The adequacy of the selected content (up to a maximum of 10 points) and a meaningful structure of the presentation, reflected in the use of media and aid, including timely submission of the handout (up to a maximum of 10 points).

The evaluation of the language consists of (a total of 40 points): The correct use of grammar (up to a maximum of 20 points), the vocabulary used (up to a maximum of 10 points) and the use of structuring phrases (up to a maximum of 10 points).

The evaluation of the execution is made up of (a total of 40 points): The free and fluent speech (up to a maximum of 15 points), the pronunciation (up to a maximum of 5 points), the listener reference (up to a maximum of 5 points) and the interaction during the concluding discussion (up to a maximum of 15 points).

Workload
A total of about 120 hours, composed of:
1. attendance time in the language course (approx. 60 SWS)
2. preparation/post-processing of the above (approx. 60 hours)
3. exam preparation and attendance of the above (approx. 15 hours)

Recommendation
Strong motivation to self-study
Module: German at ID B2.1 [M-IDSCHOOLS-104606]

Responsible: Katrina Pangritz

Organisation:
Part of: Interdisciplinary Qualification Additional Examinations

Credits 4
Grading scale Grade to a tenth
Recurrence Each winter term
Duration 1 term
Language German
Level 4
Version 4

Mandatory
T-IDSCHOOLS-110703 German at ID B2.1 - Written Examination
4 CR Pangritz

Competence Certificate
The results of the module will be assessed in the form of a 120-minute written examination and a presentation (examination of another type) pursuant to § 4 Para. 2 No. 1 and No. 3, SPO Master "Optics & Photonics".

Prerequisites
Successful completion of German level B1.2 or German B1

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:
1. at least 80% attendance in the course during the semester
2. passing 2 out of 3 tests written during the semester as a performance test
3. submission of 2 out of 3 written homework assignments (texts) during the semester
4. presentation

Competence Goal
Participants will be able to understand the main ideas of complex texts on both concrete and abstract topics; they will also be able to understand technical discussions in their own field of specialization. They are able to communicate fluently and spontaneously to a certain degree, so that a regular conversation with native speakers is quite possible without much effort on both sides. They can express themselves clearly and in detail on a wide range of subjects, explain a viewpoint on a topical issue and indicate the advantages and disadvantages of various options.

Participants can communicate about friends, company, media, education / after school life, body awareness and the urban experience.

Content
In addition to the linguistic actions already mentioned in the "Competence Goals", it is also a matter of teaching grammatical skills, namely two-part connectors, midfield in the main clause (word order), word formation: pre- and suffixes in nouns, suffixes in adjectives, stative passive voice, von / durch in passive voice clauses, passive voice in Perfekt tense, passive alternatives, causal, conditional, modal, adversative, final, and temporal connections, reference words, modal verbs and their alternatives, nouns with preposition, fixed noun-verb compounds.
Module grade calculation
The module grade consists of 75 % of the written examination at the end of the semester and 25 % of a presentation. The examination lasts 120 minutes and includes all the skills practiced during the semester, namely listening and reading comprehension, writing and grammar.

The presentation, in which a technical process is to be described to the audience, should take approx. 15 minutes. A handout should be prepared, including a list of expressions used in the presentation. The preparation of a PowerPoint presentation is optional.

The grade of the presentation is based on the evaluation of the following criteria and results in a total of max. 100 points:
- The chosen content (max. 20 points)
- The used language (max. 40 points)
- The execution (max. 40 points)

These three criteria are subdivided as follows:

The evaluation of the content is divided into (a total of 20 points): The adequacy of the selected content (up to a maximum of 10 points) and a meaningful structure of the presentation, reflected in the use of media and aid, including timely submission of the handout (up to a maximum of 10 points)

The evaluation of the language consists of (a total of 40 points): The correct use of grammar (up to a maximum of 20 points), the vocabulary used (up to a maximum of 10 points) and the use of structuring phrases (up to a maximum of 10 points).

The evaluation of the execution is made up of (a total of 40 points): The free and fluent speech (up to a maximum of 15 points), the pronunciation (up to a maximum of 5 points), the listener reference (up to a maximum of 5 points) and the interaction during the concluding discussion (up to a maximum of 15 points).

Recommendation
Strong motivation for self-study
2.22 Module: German at ID B2.2 [M-IDSCHOOLS-104607]

**Responsible:** Katrina Pangritz  
**Organisation:**  
**Part of:** Interdisciplinary Qualification  
Additional Examinations

<table>
<thead>
<tr>
<th>Credits</th>
<th>Grading scale</th>
<th>Recurrence</th>
<th>Duration</th>
<th>Language</th>
<th>Level</th>
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<td>Each summer term</td>
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<td>German</td>
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**Mandatory**

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<th>Description</th>
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<td>German at ID B2.2 - Written Examination</td>
<td>4</td>
<td>CR</td>
<td>Pangritz</td>
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**Competence Certificate**
The results of the module will be assessed in the form of a 120-minute written examination and a presentation (examination of another type) pursuant to § 4 Para. 2 No. 1 and No. 3, SPO Master "Optics & Photonics".

**Prerequisites**
Successful completion of German level B2.1

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester
2. passing 2 out of 3 tests written during the semester as a performance test
3. submission of 2 out of 3 written homework assignments (texts) during the semester
4. presentation

**Competence Goal**
Participants will be able to understand the main ideas of complex texts on both concrete and abstract topics; they will also be able to understand technical discussions in their own field of specialization. They are able to communicate fluently and spontaneously to a certain degree, so that a regular conversation with native speakers is quite possible without much effort on both sides. They can express themselves clearly and in detail on a wide range of subjects, explain a viewpoint on a topical issue and indicate the advantages and disadvantages of various options.

Participants will be able to exchange views on relationships, nutrition, life at university, service, health, language and regions.

**Content**
In addition to the linguistic actions already mentioned in the "Competence Goals", it is also a matter of teaching grammatical skills, namely adjectives with preposition, adverb-verb compounds, word formation: pre- and suffixes in nouns, verbs, adverbs and adjectives, nominalization of verbs, local prepositions and expressions, temporal expressions, subjective meaning of modal verbs, generalizing relative clauses, relative clauses with wo(r)- and preposition, consecutive and concessive connections, subjunctive II (unreal conditions, desires and comparisons), indirect speech, subjectless passive clauses, extended participle constructions, the word es as sentence element, fixed noun-verb compounds.
Module grade calculation
The module grade consists of 75 % of the written examination at the end of the semester and 25 % of a presentation. The examination lasts 120 minutes and includes all the skills practiced during the semester, namely listening and reading comprehension, writing and grammar.

The presentation, in which a scientific topic (e.g. subject of Master thesis or research) of the participant’s field of study is to be introduced to the audience, should take approx. 20 minutes. A handout should be prepared, including a list of expressions used in the presentation. The preparation of a PowerPoint presentation is optional.

The grade of the presentation is based on the evaluation of the following criteria and results in a total of max. 100 points:
- The chosen content (max. 20 points)
- The used language (max. 40 points)
- The execution (max. 40 points)

These three criteria are subdivided as follows:

The evaluation of the content is divided into (a total of 20 points): The adequacy of the selected content (up to a maximum of 10 points) and a meaningful structure of the presentation, reflected in the use of media and aid, including timely submission of the handout (up to a maximum of 10 points).

The evaluation of the language consists of (a total of 40 points): The correct use of grammar (up to a maximum of 20 points), the vocabulary used (up to a maximum of 10 points) and the use of structuring phrases (up to a maximum of 10 points).

The evaluation of the execution is made up of (a total of 40 points): The free and fluent speech (up to a maximum of 15 points), the pronunciation (up to a maximum of 5 points), the listener reference (up to a maximum of 5 points) and the interaction during the concluding discussion (up to a maximum of 15 points).

Workload
A total of about 120 hours, composed of:

1. attendance time in the language course (approx. 60 SWS)
2. preparation/post-processing of the above (approx. 60 hours)
3. exam preparation and attendance of the above (approx. 15 hours)

Recommendation
Strong motivation for self-study
2.23 Module: German at ID C1.1 [M-IDSCHOOLS-105583]

Responsible: Katrina Pangritz

Organisation:
Part of: Interdisciplinary Qualification Additional Examinations

<table>
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<tr>
<th>Credits</th>
<th>Grading scale</th>
<th>Recurrence</th>
<th>Duration</th>
<th>Language</th>
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Mandatory
T-IDSCHOOLS-111198 German at ID C1.1 - written examination 4 CR Pangritz

Competence Certificate
The results of the module will be assessed in the form of a 120-minute written examination and a presentation (examination of another type) pursuant to § 4 Para. 2 No. 1 and No. 3, SPO Master "Optics & Photonics".

Prerequisites
Successful completion of German level B2.2 or B2

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester
2. passing 2 out of 3 tests written during the semester as a performance test
3. submission of 2 out of 3 written homework assignments (texts) during the semester
4. presentation

Competence Goal
Participants can understand a wide range of demanding, longer texts and can recognize implicit meaning. They can interact spontaneously and fluently without much obvious searching for expressions. Participants can use language flexibly and effectively for social, academic and professional purposes, and express themselves clearly, in a well-structured and detailed manner on complex issues, making appropriate use of various organizational and cohesive means.

Can use language flexibly and effectively for social, academic and professional purposes. Can produce clear, well-structured, detailed text on complex subjects, showing controlled use of organizational patterns, connectors and cohesive devices.

Content
In addition to the linguistic actions already mentioned in the "Competence Goals", the course also focuses on the teaching of grammatical skills, namely the subjective meaning of modal verbs, word formation with different prefixes, two-part concessive and restrictive connectors, fixed noun-verb compounds, modal verbs and their alternatives, unreal follow-on clauses, adjective declension according to article words, adjectives and indefinite numerals, es as (non-)obligatory sentence element, graduation of adjectives, indirect speech, reference words and prepositions.

Module grade calculation
The module grade consists of 75 % of the written examination at the end of the semester and 25 % of a presentation. The examination lasts 120 minutes and includes all the skills practiced during the semester, namely listening and reading comprehension, writing and grammar.

The presentation, in which a current topic from the German media or those of the home country is to be introduced and explained to the audience in detail, should take approx. 20 minutes. A handout should be prepared, including a list of expressions used in the presentation. The preparation of a PowerPoint presentation is optional.

The grade of the presentation is based on the evaluation of the following criteria and results in a total of max. 100 points:
- The chosen content (max. 20 points)
- The used language (max. 40 points)
- The execution (max. 40 points)

These three criteria are subdivided as follows:

The evaluation of the content takes into account (a total of 20 points): The adequacy of the selected content (up to a maximum of 10 points) and a meaningful structure of the presentation, reflected in the use of media and aid, including timely submission of the handout (up to a maximum of 10 points).

The evaluation of the language consists of (a total of 40 points): The correct use of grammar (up to a maximum of 20 points), the vocabulary used (up to a maximum of 10 points) and the use of structuring phrases (up to a maximum of 10 points).

The evaluation of the execution is made up of (a total of 40 points): The free and fluent speech (up to a maximum of 15 points), the pronunciation (up to a maximum of 5 points), the listener reference (up to a maximum of 5 points) and the interaction during the concluding discussion (up to a maximum of 15 points).
Workload
A total of about 120 hours, composed of:

1. attendance time in the language course (approx. 60 SWS)
2. preparation/post-processing of the above (approx. 60 hours)
3. exam preparation and attendance of the above (approx. 15 hours)

Recommendation
Strong motivation for self-study
2.24 Module: Imaging Techniques in Light Microscopy [M-CHEMBIO-101905]

 Responsible: Prof. Dr. Martin Bastmeyer
 Organisation: KIT Department of Chemistry and Biosciences
 Part of: Specialization - Biomedical Photonics (Compulsory Elective Modules)

<table>
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<th>Credits</th>
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<th>Recurrence</th>
<th>Duration</th>
<th>Language</th>
<th>Level</th>
<th>Version</th>
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<td>Each winter term</td>
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<td>English</td>
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</table>

**Mandatory**

| TCHEMBIO-105197 | Imaging Techniques in Light Microscopy | 3 CR | Bastmeyer |

**Competence Certificate**

Written exam over 120 minutes (depending on the number of participants oral exam over approx. 45 min).

**Modality of Exam:** Depending on the number of participants, a written or an oral exam is accomplished. The exact modality of the exam will be announced at the beginning of the semester. The written exam is scheduled for the beginning of the break after the WS. A resit exam is offered at the end of the break.

**Prerequisites**

none

**Competence Goal**

The students

- are able to derive the description of geometric- and wave-optical principles of a compound microscope
- know the physical principles of fluorescent dyes
- understand the configuration of laser scanning microscopes
- comprehend digital imaging and image processing
- have experienced a hands on laboratory praxis of the different microscopic techniques
- understand the biological principles of GFP-expression
- know the latest developments in light microscopy
- understand how technical development of microscopes has driven basic biological research

**Content**

This lecture series is designed to gain familiarity with fundamentals of biological light microscopy and modern fluorescence techniques. Depending on the content, the students will have lab demonstrations of different microscopes or imaging techniques covered in the lecture.

I. Introduction (History and Basic Principles of Compound Microscopes, Resolution and Contrast, Biological Sample Preparation)

II. Imaging Modes and Contrast Techniques (Biological Amplitude and Phase Objects, Phase Contrast, Interference Contrast, Polarization Microscopy)

III. Fluorescence Microscopy (Microscopic Principles, Fluorescent Dyes and Proteins, Biological Sample Preparation)

IV. Laser-Scanning-Microscopy (Basic Principles, Spinning Disk, 2-Photon Microscopy, Optical Sectioning Techniques)

V. Live Cell Imaging (Video Microscopy, Fluorescent Proteins)

VI. Special Fluorescence Techniques (FRET, TIRF, FCS)

VII. Super Resolution Microscopy (SIM, PALM, dSTORM, STED)

VIII. Digital images (Image Processing, Data Analysis and Quantification)

**Workload**

Total 90 h, hereof 30h contact hours (30h lecture), and 60h homework and self-studies

**Recommendation**

Attendance to the lecture. Basic knowledge in physics and biology.

**Learning type**

Lecture (including demonstration of microscopic techniques in the laboratory)

**Literature**

Lecture presentations will be accessible in pdf-format

Recent review articles will be distributed before the lectures

Books:

- Alan R. Hibbs: Confocal Microscopy for Biologists, Springer Press
- Rafael Yuste (Ed.): Imaging, a laboratory manual, CSH Press
- James Pawley: Handbook of biological confocal microscopy, Plenum Press

Optics and Photonics Master 20151 (Master of Science (M.Sc.))

Module Handbook as of 24/10/2022
Module: Internship [M-ETIT-102360]

Responsible: Prof. Dr. Ulrich Lemmer
Prof. Dr.-Ing. Christoph Stiller

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Internship

<table>
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<th>Credits</th>
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<th>Recurrence</th>
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<th>Language</th>
<th>Level</th>
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<td>English</td>
<td>5</td>
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</tbody>
</table>

Competence Certificate
The internship is a study achievement (study and examinations Regulation, § 4 (3)). A minimum of working hours equivalent to 8 weeks of full-time work (excluding holidays and public holidays) must be completed.

Furthermore the following must be provided:
1: A company confirmation about the completion of the internship

**Internship confirmation/certificate from industry or research institute.**
The internship confirmation is issued directly by the company or institute, respectively, after the internship is completed. The confirmation should be signed by the local supervisor and contain the following information (1) the student's name, birthday and matriculation number, (2) start and end date of the internship (minimum eight weeks without vacations), (3) the title of the project, and (4) Company Name (institute, sector and supervisor). Please note that the internship contract is not valid as a certificate.

2. Delivery of a written report on methodology and results (approx. 10 pages).
The internship report comprises a written report in the form of a seminar paper and an evaluation to be handed in to the KSOP student office.

-> Both documents (company confirmation and internship report) have to be send to the KSOP Office latest 2 weeks before the presentation date.

3. Presentation
In the internship presentation the students have to present the project work of their internships to a KSOP professor and their peers (who make the presentation on the same day; usually up to 15 students) followed by a discussion of the results.

For the presentation several dates (usually one every three month) are available per year. The dates are announced twice a year to the current students and students need to register online for the desired presentation date latest 15 days before the desired presentation date. After that the registration will be closed.

The 12 credit points are awarded after passing the company confirmation, internship report and presentation. The decision is made by a KSOP professor.

**Prerequisites**
Scientific background in Optics and Photonics
Competence Goal
The students gather insight in procedures and practical work in industry or research institutions. They acquire hands-on experience in a concise practical task related to a future job profile in the field of Optics and Photonics, be it in research or industry. They can participate in and contribute to an interdisciplinary team and are able to present their work in discussions with others. They are able to transfer their theoretical knowledge into practical solutions to real-world problems.

The students
- understand work procedures and methodology in an industrial or a research institution.
- understand requirements in an industrial or research environment.
- understand the interrelation of theoretical findings, simulations, experimental studies and practical solutions in Optics and Photonics.

- are able to systematically approach a practical problem.
- gather experience in interdisciplinary teamwork and are able to express their knowledge in such an environment.
- are able to scientifically report and present their work.

Content
The students are exposed to Optics and Photonics industry or a research institution and get involved in the solution of a concise real-world problem in that domain.

Workload
total 360 h including 8-week (320 h) project work in industry plus 40 h of report writing and presentation of results

Recommendation
Scientific background in Optics and Photonics

Learning type
Internship

Literature
Individual literature will be provided by the external internship advisor.
Module: Introduction to Automotive and Industrial Lidar Technology [M-ETIT-105461]

**Responsible:** Prof. Dr. Wilhelm Stork

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** Specialization - Optical Systems

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**Mandatory**

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<th>Language</th>
<th>Level</th>
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<td>Each winter term</td>
<td>1 term</td>
<td>English</td>
<td>4</td>
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</tbody>
</table>

**Module grade calculation**

The module grade results of the assessment of the oral exam and the short oral presentation. Details will be given during the lecture.

**Workload**

1. participation in the lectures 12h - 8 dates á 1.5h
2. preparation and postprocessing 14 h (2h for VL dates 1-7)
3. preparation of the short lecture (16h)
4. preparation and participation in the oral exam: 48h

**Recommendation**

Basics of optics / optical technologies are helpful (e.g. optical engineering, optoelectronic, technical optics)
Module: Introduction to the Scientific Method (Seminar, English) [M-ETIT-105665]

Responsible: Prof. Dr. Werner Nahm
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Interdisciplinary Qualification

<table>
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<td>1 term</td>
<td>English</td>
<td>4</td>
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</table>

Mandatory

T-ETIT-111317 Introduction to the Scientific Method (Seminar, Englisch) 1 CR Nahm

Competence Certificate
The success control takes place in the form of a study achievement. The exam consists of the preparation and the presentation of a seminar paper.

Prerequisites
none

Competence Goal
- The students can describe and explain the scientific method using examples.
- The students can critically evaluate the implementation of the scientific method using the example of selected publications.
- The students can structure their own topic along the scientific method.
- The students can derive and formulate key questions and hypotheses on a research topic using their own example.

Content
The seminar is a combination of lecturer presentations and discussion, as well as student presentations and discussions. The block course consists of three parts:
- Part 1: Basics and presentation of the method
- Part 2: Applying the method to analyze selected examples
- Part 3: Application of the method for structuring one's own research topic
The seminar deals with the questions:
- what is science?
- what is scientific?
- what is the scientific method?
- what is a scientific design?

The seminar sheds light on classical and modern approaches to the theory of science, in particular critical rationalism.

The seminar develops definitions and delimitations of the terms:
- research topic
- leading question
- thesis
- hypothesis
- assumption
- theory

The seminar develops a simple and practical recipe for the scientific design of publications, theses and dissertations. The recipe is used by the seminar participants to analyze selected scientific work and to structure their own scientific work.

Module grade calculation
The seminar is passed by successful submission and presentation of the seminar paper.

Annotation
The course is held as a block in the second half of each semester.
Workload
1. attendance times in lectures and exercises: $7 \times 1,5h = 10,5h$
2. preparation of lectures and exercises $7 \times 1,5h = 10,5h$
3. preparation of the seminar paper: 10h
2.28 Module: Laser Metrology [M-ETIT-100434]

Responsible: Prof. Dr. Marc Eichhorn
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Specialization - Optical Systems
Specialization - Quantum Optics & Spectroscopy
Additional Examinations

Credits 3  Grading scale Grade to a tenth
Recurrence Each summer term  Duration 1 term  Language English  Level 4  Version 1

Mandatory
T-ETIT-100643 Laser Metrology  3 CR Eichhorn

Competence Certificate
The exam will be taken as an oral examination (about 20 minutes). The individual appointments for examination are offered regularly.

Prerequisites
none

Competence Goal
The students understand the fundamental properties of laser light and possess the knowledge necessary to understand the metrologically obtainable information, understand the basics of various detectors as well as their limits and have the knowledge necessary to understand a multitude of laser metrological setups, mainly for interferometry, Moiré methods, distance and velocity measurements and absorption as well as scattering techniques.

Content
In the module several aspects of laser diagnostics will be discussed, beginning with the fundamental properties of laser light and the related metrologically useful information. In addition beam diagnostics and interferometric setups in general, as well as Moiré methods in particular, will be discussed. Further topics of the lecture will be commonly used setups, mainly for laser distance and velocity measurements along with widely used absorption and scattered light methods.

1. Laser diagnostics - theoretical considerations (laser beam properties, coherence, spectral emission of lasers, mode structure and selection, coherence length)
2. Metrological accessible information (propagation in homogeneous and isotropic, in inhomogeneous and in anisotropic media)
3. Beam diagnostics (photoelectric detectors, information theory, granulation properties of laser light)
4. Laser-Interferometer (fundamentals, two-beam Interferometer, interferometry applications in plasma physics, two- and multiwavelength-interferometry, laser gyroscopes)
5. Moiré technique (Moiré deflectometry, Fresnel- and Fraunhofer diffraction, applications and evaluation of the Moiré technique)
6. Laser range measurements (fundamentals, atmospheric influence on propagation, optical distance measurement techniques, accuracy, sensitivity, heterodyne detection, selected heterodyne detection schemes, tomoscopy)
7. Laser velocity measurement techniques (Doppler principle, measuring flow velocities using Doppler effect, the two-focus technique or laser anemometry; time-resolved imaging particle-trace anemometry)
8. Absorption and scattering techniques (absorption techniques, LIDARs, scattering processes in laser diagnostics, spontaneous scattering techniques, spectroscopic techniques, stimulated scattering, nonlinear optical laser light scattering techniques)

Module grade calculation
The module grade is the grade of the oral exam.

Workload
About 90 h in total, consisting of
30 h lectures
60 h recapitulation and self-studies

Literature
M. Eichhorn, Laser metrology - Scriptum
A. E. Siegman, Lasers (university Science Books)
B. E. A. Saleh, M. C. Teich, Fundamentals of Photonics (Wiley-Interscience)
2.29 Module: Laser Physics [M-ETIT-100435]

**Responsible:** Prof. Dr. Marc Eichhorn

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:**
- Specialization - Photonic Materials and Devices
- Specialization - Biomedical Photonics (Compulsory Elective Modules)
- Specialization - Optical Systems
- Specialization - Quantum Optics & Spectroscopy

**Additional Examinations**

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**Mandatory**

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<th>Duration</th>
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<td>Laser Physics</td>
<td>4</td>
<td>CR</td>
<td>Each winter term</td>
<td>1 term</td>
<td>English</td>
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</tbody>
</table>

**Competence Certificate**
The exam will be taken as an oral examination (about 20 minutes). The individual appointments for examination are offered regularly.

**Prerequisites**
none

**Competence Goal**
The students understand the fundamental relations and basics of a laser. They obtain the knowledge necessary for understanding and designing lasers (laser media, optical resonators, pumping schemes) and understand the basics and schemes for pulse generation in a laser. They have the knowledge needed for a multitude of lasers: gas, solid-state, fiber and disc lasers from the visible up to the mid-Infrared spectrum.
Content
Within the module the physical basics of lasers, the fundamental processes of light amplification and the formalisms necessary to describe lasers and laser resonators are covered. The generation of laser pulses and various laser architectures as well as realisations are presented in detail.

The exercises specifically discuss the topics of laser description, theoretical background as well as the realization of different laser designs. The tasks of the exercise will be handed out at the end of each lecture as well as uploaded to the lecture website and are to be solved for the following exercise, in which the solution will be discussed.

Contents:
1 Quantum-mechanical fundamentals of lasers
   1.1 Einstein relations and Planck’s law
   1.2 Transition probabilities and matrix elements
   1.3 Mode structure of space and the origin of spontaneous emission
   1.4 Cross sections and broadening of spectral lines
2 The laser principles
   2.1 Population in version and feedback
   2.2 Spectroscopic laser rate equations
   2.3 Potential model of the laser
3 Optical Resonators
   3.1 Linear resonators and stability criterion
   3.2 Mode structure and intensity distribution
   3.3 Line width of the laser emission
4 Generation of short and ultra-short pulses
   4.1 Basics of Q-switching
   4.2 Basics of mode locking and ultra-short pulses
5 Laser examples and their applications
   5.1 Gas lasers: The Helium-Neon-Laser
   5.2 Solid-state lasers
      5.2.1 The Nd3+-Laser
      5.2.2 The Tm3+-Laser
      5.2.3 The Ti3+:Al2O3 Laser
   5.3 Special realisations of lasers
      5.3.1 Thermal lensing and thermal stress
      5.3.2 The fiber laser
      5.3.3 The thin-dis laser

Module grade calculation
The module grade is the grade of the oral exam.

Workload
About 120 h in total, consisting of
30 h lectures
15 h tutorial
75 h recapitulation and self-studies

Literature
M. Eichhorn, Laser physics (Springer)
M. Eichhorn, Laserphysik (Springer)
A. E. Siegman, Lasers (University Science Books)
B. E. A. Saleh, M. C. Teich, Fundamentals of Photonics (Wiley-Interscience)
F. K. Kneubühl, M. W. Sigrist, Laser (Teubner)
Module: Light and Display Engineering [M-ETIT-100512]

Responsible: Dr.-Ing. Rainer Kling
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Specialization - Optical Systems
Additional Examinations

Credits 4
Grading scale Grade to a tenth
Recurrence Each winter term
Duration 1 term
Language English
Level 4
Version 1

Mandatory
T-ETIT-100644 Light and Display Engineering 4 CR Kling

Competence Certificate
Type of Examination: Oral exam
Duration of Examination: approx. 25 minutes
Modality of Exam: The oral exam is flexibly held by student request after the WS.

Prerequisites
none

Competence Goal
The students will apply their comprehensive knowledge of physics of optical phenomena to applied optical systems in light and display engineering. These applications span from human sensing with the eye to light technologies with lamps, luminaires and displays. The course gives a broad overview how optics can be applied in modern technology fields. The subjects taught are further clarified by demonstrations, models and experiments.

The students

• can derive the description of basic of light engineering starting from the eye and the visual system
• know how to handle basic metrical units and know how to measure them
• understand the visible sensing in contrast to radiation measurements
• comprehend the concepts of colour and colour control
• are familiar with all types of light sources from low pressure lamps to LED modules
• conceive the operation principle of various types of drivers
• know how to set up a luminaire and how simulate a reflector
• they understand how active (Plasma Displays) and passive displays (TFT Display) work and how to operate them
• have a good visualization of numerous optical design approaches

Content
1. Motivation: Light & Display Engineering
2. Light, the Eye and the Visual System (including Melatonin)
3. Fundamentals in Light Engineering
4. Light in non-visual Processes (UV Processes)
5. Color and Brightness
6. Light Sources (Halogen, Low Pressure and High Pressure Lamps, LED Engines) and electronic Drivers
7. Displays (Active and Passive Displays: AMOLED, E-ink, TFT Display, Plasma Display)
8. Luminaries (Fundamentals, Design Rules, Simulations)
9. Optical Design (Ray tracing, Reflector design, Computed Ray tracing)

Module grade calculation
The module grade is the grade of the oral exam.

Workload
total 120 h, hereof 45 h contact hours (lecture and tutorial), and 75 h homework and self-studies

Recommendation
Basic physics background
Literature
Shunsuke Kobayashi: LCD Backlights, 2009
Malacara, Handbook of Optical Design, 2004
2.31 Module: Lighting Design - Theory and Applications [M-ETIT-100577]

Responsible: Dr.-Ing. Rainer Kling
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Specialization - Optical Systems

Additional Examinations

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<th>Credits</th>
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Mandatory

| T-ETIT-100997 | Lighting Design - Theory and Applications | 3 CR | Kling |

Competence Certificate

Type of Examination: Oral exam
Duration of Examination: approx. 25 minutes
Modality of Exam: The oral exam is flexibly held by student request after the WS.

Prerequisites

none

Competence Goal

The students will apply a comprehensive knowledge of Lighting Design from theory, standards and applications in Indoor and Outdoor lighting. Examples and own Lighting design examples as projects. So a practical and theoretical background is applied to Lighting Design. From metrics too Light Planning projects in small exercise groups. The subjects taught are further clarified by demonstrations, models and experiments. Attending students get the knowledge to Lighting Design, in a shorter theoretical part and practical lighting design simulations with examples from all over the world.

The students

- can derive the description of basics of Lighting Design
- know how to handle basic metrical units and know how to measure them
- understand the Lighting Design metrics to apply on projects
- have a good visualization of numerous design approaches
- realize good Lighting Design with codes and standards.
- can see energy savings levels for Lighting Design
- comprehend the lighting design by practical self-computing lessons:
- can realize own indoor Lighting design concepts for different applications like Office, School, Shops, Gyms & Industry
- can realize own outdoor Lighting Design concepts for Street lighting, Tunnels, Stade and Parkings
- can use for realization Relux and Dialux light planning software so set up Project Planning for Lighting Design.

Content

1. Lighting Design - Introduction form all over the world
2. Lighting Fundamentals
3. Lighting Design Theory
4. Energy Savings and Lighting design
5. Lighting Design Tools
6. Computing Standards
7. Lightning Design Applications (Practical Part)
   7.1 Interior Lighting
   7.2 Exterior lighting
7.3 IlluminationOwn Calculation Examples (Practical Part)Motivation: Light & Display Engineering
8. Own Calculation Examples (Practical Part)Motivation: Light & Display Engineering

Module grade calculation

The module grade is the grade of the oral exam.

Workload

total 90 h, hereof 45 h contact hours (Seminar), and 45 h homework and self-studies
Recommendation
Hearing first M-ETIT-100512 - Light and Display Engineering lecture is beneficial.

Literature
M. Karlen: Lighting Design Basics, Indoor Lightin, 2004
R.H. Simons Lighting Engineering, 2001
2.32 Module: Machine Vision [M-MACH-101923]

**Responsible:** Dr. Martin Lauer  
Prof. Dr.-Ing. Christoph Stiller

**Organisation:** KIT Department of Mechanical Engineering

**Part of:** Specialization - Optical Systems  
Additional Examinations

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**Mandatory**

| T-MACH-105223 | Machine Vision | 8 CR | Lauer, Stiller |

**Competence Certificate**

Type of Examination: written exam  
Duration of Examination: 60 minutes

**Prerequisites**

None

**Competence Goal**

After having participated in the lecture the participants have gained knowledge on modern techniques of machine vision and pattern recognition which can be used to evaluate camera images. This especially includes techniques in the areas of gray level image analysis, analysis of color images, segmentation of images, describing the geometrical relationship between the image and the 3-dimensional world, and pattern recognition with various classification techniques. The participants have learned to analyze the algorithms mathematically, to implement them in software, and to apply them to tasks in video analysis. The participants are able to analyze real-world problems and to develop appropriate solutions.
Content
The lecture on machine vision covers basic techniques of machine vision. It focuses on the following topics:
image preprocessing
edge and corner detection
curve and parameter fitting
color processing
image segmentation
camera optics
pattern recognition
deep learning

Image preprocessing:
The chapter on image processing discusses techniques and algorithms to filter and enhance the image quality. Starting from an analysis of the typical phenomena of digital camera based image capturing the lecture introduces the Fourier transform and the Shannon-Nyquist sampling theorem. Furthermore, it introduces gray level histogram based techniques including high dynamic range imaging. The discussion of image convolution and typical filters for image enhancement concludes the chapter.

Edge and corner detection:
Gray level edges and gray level corners play an important role in machine vision since gray level edges often reveal valuable information about the boundaries and shape of objects. Gray level corners can be used as feature points since they can be identified easily in other images. This chapter introduces filters and algorithms to reveal gray level edges and gray level corners like the Canny edge detector and the Harris corner detector.

Curve and parameter fitting:
In order to describe an image by means of geometric primitives (e.g. lines, circles, ellipses) instead of just pixels robust curve and parameter fitting algorithms are necessary. The lecture introduces and discusses the Hough transform, total least sum of squares parameter fitting as well as robust alternatives (M-estimators, least trimmed sum of squares, RANSAC).

Color processing:
The short chapter on color processing discusses the role of color information in machine vision and introduces various models for color understanding and color representation. It concludes with the topic of color consistency.

Image Segmentation:
Image segmentation belongs to the core techniques of machine vision. The goal of image segmentation is to subdivide the image into several areas. Each area shares common properties, i.e. similar color, similar hatching, or similar semantic interpretation. Various ideas for image segmentation exist which can be used to create more or less complex algorithms. The lecture introduces the most important approaches ranging from the simpler algorithms like region growing, connected components labeling, and morphological operations up to highly flexible and powerful methods like level set approaches and random fields.

Camera optics:
The content of an image is related by the optics of the camera to the 3-dimensional world. In this chapter the lecture introduces optical models that describe the relationship between the world and the image including the pinhole camera model, the thin lens model, telecentric cameras, and catadioptric sensors. Furthermore, the lecture introduces camera calibration methods that can be used to determine the optical mapping of a real camera.

Pattern recognition:
Pattern recognition aims at recognizing semantic information in an image, i.e. not just analyzing gray values or colors of pixels but revealing which kind of object is shown by the pixels. This task goes beyond classical measurement theory and enters the large field of artificial intelligence. Rather than just being developed and optimized by a programmer, the algorithms are adapting themselves to their specific task using training algorithms that are based on large collections of sample images.

The chapter of pattern recognition introduces standard techniques of pattern recognition in the context of image understanding like the support vector machine (SVM), decision trees, ensemble and boosting techniques. It combines those classifiers with powerful feature representation techniques like the histogram of oriented gradients (HOG) features, locally binary patterns (LBP), and Haar features.

Deep learning:
Throughout recent years standard pattern recognition techniques have more and more been outperformed by deep learning techniques. Deep learning is based on artificial neural networks, a very generic and powerful form of a classifier. The lecture introduces multi layer perceptrons as the most relevant form of artificial neural networks, discusses training algorithms and strategies to achieve powerful classifiers based on deep learning including deep auto encoders, convolutional networks, and multi task learning, among others.

Workload
240 hours, composed out of
hours of lecture: 15*4 h = 60 h
preparation time prior to and after lecture: 15*6 h = 90 h
exam preparation and exam: 90 h
Learning type
Lecture

Literature
Main results are summarized in the slides that are made available as pdf-files. Further recommendations will be presented in the lecture.
2.33 Module: Measurement and Control Systems [M-MACH-101921]

Responsible: Prof. Dr.-Ing. Christoph Stiller
Organisation: KIT Department of Mechanical Engineering

Part of: Adjustment Courses (Modern Physics / Measurement and Control Systems)

Mandatory

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Competence Certificate
Type of Examination: written exam
Duration of Examination: 150 minutes

Prerequisites
None

Competence Goal
The students

- possess knowledge in the theory of linear time-invariant systems in time domain, state space, and frequency domain
- can formulate a system model for practical devices
- can design a controller and assess closed-loop stability of the control loop
- understand the basic concept of measurement uncertainty and its propagation
- are able to estimate parameters from measurements
- understand the process and methodology of control engineering
- gather insight on interdisciplinary modelling for control of large and complex systems

Content
I. Dynamic systems
II. Properties of important systems and modeling
III. Transfer characteristics and stability
IV. State-space description
V. Controller design
VI. Fundamentals of measurement
VII. Estimation
VIII. Sensors
IX. Introduction to digital measurement

Workload
180 hours

Recommendation
Fundamentals in physics and electrical engineering, ordinary linear differential equations, Laplace transform

Literature
C. Stiller: Measurement and Control, scriptum
R. Dorf and R. Bishop: Modern Control Systems, Addison-Wesley
Module: Modern Physics [M-PHYS-101931]

Responsibility: apl. Prof. Dr. Bernd Pilawa
Organisation: KIT Department of Physics
Part of: Adjustment Courses (Modern Physics / Measurement and Control Systems)

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<tr>
<td>T-PHYS-103629</td>
<td>Modern Physics</td>
<td>6 CR</td>
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Competence Certificate
See components of this module

Prerequisites
none

Competence Goal
The students from different backgrounds refresh and elaborate their knowledge of basic physics. They comprehend the fundamentals of quantum physics and their application to atoms, nuclei and particles. They learn how to describe physical laws in a mathematical form and how to solve problems in modern physics by mathematical evaluation of these physical laws.

Learning targets
The students

- are familiar with the basic experimental results leading to Maxwell's equations
- know how to apply Maxwell's equations to simple problems in electromagnetism
- conceive the relation between relativity and electromagnetism
- comprehend the coherence of the particle and wave description of light and matter
- understand the basic principles leading to the Schrödinger-equation
- are able to apply the Schrödinger-equation to basic problems in quantum mechanics
- comprehend the limits of wave mechanics
- have a good understanding of atoms with many electrons
- know the fundamental properties of solids and especially the properties of electrons in crystalline solids.

Content
I. Introduction
II. Electromagnetism
III. Special Relativity
IV. Quantum mechanics
V. Atoms
VI. Solids

Recommendation
Solid mathematical background, basic knowledge in physics

Literature
Paul A. Tipler: Physics for engineers and scientists
Paul A. Tipler: Modern Physics
2.35 Module: Module Master's Thesis [M-ETIT-106212]

Responsibility: Prof. Dr. Cornelius Neumann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Master's Thesis

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Mandatory

| T-ETIT-112630 | Master's Thesis | 30 CR | Neumann |

Competence Certificate
Written thesis and a presentation.

Prerequisites
Prerequisited for the registration of the master's thesis are regulated in §14 (1) of the study and examination regulations. The thesis can only be started when there is a maximum of two exams left to complete. The student has to complete the internship, the O&P labs and the seminar course before starting the master's thesis.

The master's thesis can be registered at any time once the prerequisites are fulfilled.

Modeled Conditions
The following conditions have to be fulfilled:

1. You have to fulfill one of 2 conditions:
   1. The module M-PHYS-101931 - Modern Physics must have been passed.
   2. The module M-MACH-101921 - Measurement and Control Systems must have been passed.

2. The field Optics & Photonics Lab must have been passed.

3. The field Seminar Course (Research Topics in Optics & Photonics) must have been passed.

Competence Goal
Objective of the Master's Thesis is to introduce students to in depth scientific working methods. They learn to analyze an elaborate scientific problem, to develop suitable solutions, to achieve, evaluate and interpret experimental or theoretical results, and to summarize and discuss their work in a thesis.

Content
According to §14 of the study and examination regulations, the master thesis should show that students are able to work independently and in a limited time on a problem from the field of study (Optics & Photonics) according to scientific methods. Students shall be given the opportunity to make suggestions for the topic. In exceptional cases, the chairperson of the examinations board will, at the request of the student, ensure that the student receives a topic for the Master's thesis within four weeks. In this case, the topic will be issued by the chairman of the examination board. Further details are regulated by §14 of the study and examination regulations.

Module grade calculation
The thesis will be graded by the Examiner. The grade should be given not later than 8 weeks after the submission.

Annotation
You can find information regarding the registration of the Master's Thesis on ILIAS (course: KSOP Master).

Workload
900 h including writing of thesis, preparation and presentation of the final presentation.
2.36 Module: Molecular Spectroscopy [M-CHEMBIO-101902]

Responsible: Prof. Dr. Manfred Kappes
applied Prof. Dr. Andreas-Neil Unterreiner

Organisation: KIT Department of Chemistry and Biosciences

Part of: Specialization - Quantum Optics & Spectroscopy

Mandatory

T-CHEMBIO-101864 Molecular Spectroscopy 4 CR

Prerequisites
None

Competence Goal
Students will obtain a comprehensive overview of the field of molecular spectroscopy and will learn to interpret and assign molecular spectra. Starting with the quantum mechanical foundations of light-matter interactions, selection rules and structure-dependent transition energies will be derived for rotational-, vibrational- and electronic-spectroscopy. The focus is on dipole-allowed transitions in diatomic molecules. However, students will also learn about absorption/emission in small polyatomic species. Additionally, the fundamentals of Raman scattering as well as nuclear and electron spin resonance spectroscopy will be presented.

The students
• understand and can apply the quantum mechanical description of molecular rotational, vibrational and electronic spectroscopy;
• can analyse and assign microwave, vibrational, electronic and Raman spectra of diatomic and small polyatomic molecules;
• understand the interdependence between spectroscopic method, experimental design and required optical components to learn the fundamentals of electron and nuclear spin resonance spectroscopy

Content
I. Spectroscopic fundamentals: spectral regions; conversion factors; resolution; characteristic timescales; light-matter interactions; experimental configurations;
II. Quantum-mechanical treatment of light absorption; Schrödinger equation; time-dependent perturbation theory description of transitions in a two-level system; Einstein coefficients; line profiles (lifetime broadening, Doppler- and collisional broadening); saturation;
III. Diatomic molecules: transition dipole moment formalism to calculate selection rules for harmonic oscillator and rigid rotor models, occupation numbers and transition strengths, Morse potential and Pekeris equation, vibration-rotation spectroscopy; vibrational overtones and time-independent perturbation theory; Raman effect and quantum-mechanical description; couplings and complications (nuclear spin statistics, quadratic Stark effect, rotational Zeeman effect);
IV. Polyatomic molecules: rotation in classical mechanics (moment of inertia tensor; oblate and prolate rotors; asymmetric rotor); quantum-mechanical description; selection rules and correlations between symmetric and asymmetric rotors; structure determination by microwave spectroscopy; vibrations in polyatomics; degrees of freedom; Lagrangian mechanics; normal coordinates and symmetry; selection rules; GF-matrix formalism for normal coordinate analysis;
V. Introduction to electronic spectroscopy: Born-Oppenheimer approximation; Franck-Condon factors;
VI. Introduction to electron and nuclear spin resonance: basic theory and experimental setups

Literature
Atkins: Molecular Quantum Mechanics, P. Bernath: Spectra of Atoms and Molecules, Demtröder: Laser Spectroscopy
2.37 Module: Nano-Optics [M-PHYS-102146]

**Responsible:** Dr. Andreas Naber

**Organisation:** KIT Department of Physics

**Part of:**
- Specialization - Photonic Materials and Devices
- Specialization - Biomedical Photonics (Compulsory Elective Modules)
- Specialization - Solar Energy (Compulsory Elective Modules)
- Specialization - Quantum Optics & Spectroscopy

**Additional Examinations**

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<td>T-PHYS-102282</td>
<td>Nano-Optics</td>
<td>8 CR</td>
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**Competence Certificate**

Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

**Competence Goal**

The students

- improve their understanding of general principles in electrodynamics and optics
- have a deeper understanding of the theoretical background in optical imaging and its relation to phenomena on a nanoscale
- are familiar with conventional techniques in optical microscopy and make use of their knowledge for the understanding of nano-optical methods
- realize the necessity of completely new experimental concepts to overcome the constraints of classical microscopy in the exploration of optical phenomena beyond the diffraction limit
- understand the basics of different experimental approaches for optical imaging on a nanoscale
- are able to discuss pros and cons of these techniques for applications in different fields of physics and biology
- are aware of the importance of nano-optical methods for the elucidation of long-standing interdisciplinary issues

**Content**

The lecture gives an introduction to theory and instrumentation of advanced methods in optical microscopy. Emphasis is laid on far- and near-field optical techniques with an optical resolution capability on a 10- to 100-nm-scale which is well below the principal limit of classical microscopy. Applications from different scientific disciplines are discussed (e.g., nano-antennas, single-molecule detection, plasmon-polariton propagation on metal surfaces, imaging of biological cell compartments including membranes).

**Literature**

Will be mentioned in the lecture.
2.38 Module: Nonlinear Optics [M-ETIT-100430]

Responsible: Prof. Dr.-Ing. Christian Koos
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Advanced Optics & Photonics – Theory and Materials

Credits 4
Grading scale Grade to a tenth
Recurrence Each summer term
Duration 1 term
Language English
Level 4
Version 2

Mandatory
T-ETIT-101906 Nonlinear Optics 4 CR Koos

Competence Certificate
The oral exam is offered continuously upon individual appointment.

Prerequisites
none

Competence Goal
The students

• understand and can mathematically describe the effect of basic nonlinear-optical phenomena using optical susceptibility tensors,
• understand and can mathematically describe wave propagation in nonlinear anisotropic materials,
• have an overview and can quantitatively describe common second-order nonlinear effects comprising the electro-optic effect, second-harmonic generation, sum- and difference frequency generation, parametric amplification and optical rectification,
• have an overview and can quantitatively describe the Kerr effect and other common third-order nonlinear effects, comprising self- and cross-phase modulation, four-wave mixing, self-focussing, and third-harmonic generation,
• have an overview and can describe nonlinear-optical interaction in active devices such as semiconductor optical amplifiers
• conceive the basic principles of various phase-matching techniques and can apply them to practical design problems,
• conceive the basic principles electro-optic modulators, can apply them to practical design problems, and have an overview on state-of-the art devices,
• conceive the basic principles third-order nonlinear signal processing and can apply them to practical design problems.

Content
1. The nonlinear optical susceptibility: Maxwell’s equations and constitutive relations, relation between electric field and polarization, formal definition and properties of the nonlinear optical susceptibility tensor,
2. Wave propagation in nonlinear anisotropic materials
3. Second-order nonlinear effects and devices: Linear electro-optic effect / Pockels effect, second-harmonic generation, sum- and difference-frequency generation, phase matching, parametric amplification, optical rectification
4. Third-order nonlinear effects and devices: Nonlinear refractive index and Kerr effect, self- and cross-phase modulation, four-wave mixing, self-focussing, third-harmonic generation
5. Nonlinear effects in active optical devices

Module grade calculation
The module grade is the grade of the oral exam.
There is a bonus system based on the problem sets that are solved during the tutorials: During the term, 3 problem sets will be collected in the tutorial and graded without prior announcement. If for each of these sets more than 70% of the problems have been solved correctly, a bonus of 0.3 grades will be granted on the final mark of the oral exam.

Workload
Approx. 180 h – 30 h lectures, 30 h exercises, 120 h homework and self-studies

Literature
Module: Optical Engineering [M-ETIT-100456]

**Responsible:** Prof. Dr. Wilhelm Stork

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** Engineering Optics & Photonics

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### Mandatory

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**Mandatory**

| T-ETIT-100676 | Optical Engineering | 4 CR | Stork |

### Competence Certificate

Achievement will be examined in an oral examination (approx. 20 minutes).

### Prerequisites

none

### Competence Goal

The students from different backgrounds refresh and elaborate their knowledge of engineering optics and photonics. They will get to know the basic principles of optical designs. They will connect these principles with real-world applications and learn about their problems and how to solve them. The students will know about the human view ability and the eye system. After the module they will be able to judge the basic qualities of an optical system by its quantitative data.

After the course, students will:

- understand fundamental optical phenomena and apply it to solve optical engineering problems;
- work with the basic tools of optical engineering, i.e. ray-tracing by abcd-matrices;
- get a broad knowledge on real-world applications of optical engineering;
- learn about the potential of optical design for industrial, medical and day-to-day applications;
- know up-to-date optical engineering problems and its solutions.

### Content

The course "Optical Engineering" teaches the practical aspects of designing optical components and instruments such as lenses, microscopes, optical sensors and measurement systems, and optical disc systems (e.g. CD, DVD, HVD). The course explains the layout of modern optical systems and gives an overview over available technology, materials, costs, design methods, as well as optical design software. The lectures will be given in the form of presentations and accompanied by individual and group exercises. The topics of the lectures include:

I. Introduction (Optical Phenomena)
II. Ray Optics (thin/thick lenses, principal planes, ABCD-matrices, chief rays, examples: Eye, IOL)
III. Popular Applications (Magnifying glass, microscope, telescope, Time-of-flight)
IV. Wave Optics (Interference, Diffraction, Spectrometers, LDV)
V. Aberrations I (Coma, defocus, astigmatism, spherical aberration)
VI. Fourier Optics (Periodical patterns, FFT spectrum, airy-patterns)
VII. Aberration II (Seidel and Zernike Aberrations, MTF, PSF, Example: Eye)
VIII. Fourier Optics II (Kirchhoff + Fresnel, contrast, example: Hubble-telescope)
IX. Diffractive Optics Applications (Gratings, holography, IOL, CD/DVD/Blu-Ray-Player)
X. Interference (Coherence, OCT)
XI. Filters and Mirrors (Filters, antireflection, polarization, micro mirrors, DLPs)
XII. Laser and Laser Safety (Laser principle, laser types, laser safety aspects)
XIII. Displays (Pico projectors, LCD, LED, OLED, properties of displays)

### Module grade calculation

The module grade is the grade of the oral exam.

### Workload

- total 120 h, hereof 45 h contact hours (30 h lecture, 15 h problem class), and 75 h homework and selfstudies

### Recommendation

Solid mathematical background.
Literature
E. Hecht: Optics
J.W. Goodmann: Introduction to Fourier optics
K.K. Sharma: Optics - Principles and Applications
Module: Optical Networks and Systems [M-ETIT-103270]

**Responsible:** Prof. Dr.-Ing. Sebastian Randel

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** Specialization - Photonic Materials and Devices
Specialization - Optical Systems

**Credits:** 4

**Grading scale:** Grade to a tenth

**Recurrence:** Each winter term

**Duration:** 1 term

**Language:** English

**Level:** 4

**Version:** 2

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### Competence Certificate

**Type of Examination:** oral exam

**Duration of Examination:** 20 min (approx.)

**Modality of Exam:** Oral exams (approx. 20 minutes) are offered throughout the year upon individual appointment.

### Prerequisites

none

### Competence Goal

The module provides knowledge about optical networks and systems with applications ranging from photonic interconnects, to fiber-to-the-home (FTTH), optical metro and long-haul networks, and automotive and industrial automation. The role of various network layers will be discussed in conjunction with relevant standards and protocols. Physical-layer specifications of relevant photonic components and system design trade-offs will be introduced.

The students

- get familiar with optical network architectures and protocols
- learn how to design optical communication systems in a variety of application scenarios
- understand how application constraints (performance, cost, energy-efficiency) drive technology innovation
- comprehend the benefits and challenges of using optical communication compared to alternatives (e.g. electrical, and wireless)
- are familiar with relevant standardization bodies and are able to interpret essential aspects of standard documents.

### Content

Photonic interconnects: rack-to-rack, board-to-board, chip-to-chip, datacenter interconnects, intensity modulation, direct detection, single-mode fiber vs. multi-mode fiber, serial vs. parallel optics, space-division multiplexing vs. wavelength-division multiplexing, Ethernet (10G, 40G, 100G), Fibre Channel, scaling and energy efficiency.

Access networks: fiber-to-the-X, passive optical networks (GPON, EPON, NG-PON2, WDM PON), statistical multiplexing vs. point-to-point

Metro- and long-haul networks:

- System-design aspects: dense WDM (ITU grid), optical amplifiers, chromatic dispersion, coherent detection, optical vs. electronic impairment mitigation, capacity limits.
- Wavelength switching: wavelength selective switch (WSS), reconfigurable optical add-drop multiplexer (ROADM).
- Standards and protocols: synchronous optical networking and synchronous digital hierarchy (SONET/SDH), optical transport network (OTN), generalized multi-protocol label switching (GMPLS), software-defined networking (SDN).

Optical networks in automotive and industrial automation: polymer-optical fiber (POF), MOST Bus, Profinet and Profinet, optical vs. electrical communication links, overcoming bandwidth limitations using digital signal processing.

### Module grade calculation

The module grade is the grade of the oral exam.

### Workload

Total 120 h, hereof 30 h lecture, 15 h problems class and 75 h recapitulation and self-studies

### Recommendation

Interest in communications engineering, networking, and photonics.
Literature
Ivan Kaminow, Tingye Li, Alan E. Willner (Editors), Optical Fiber Telecommunications (Sixth Edition), Elsevier
Rajiv Ramaswami, Kumar N. Sivarajan and Galen H. Sasaki, Optical Networks (Third Edition), Elsevier
### 2.41 Module: Optical Systems in Medicine and Life Science [M-ETIT-103252]

**Responsible:** Prof. Dr. Werner Nahm  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** Specialization - Biomedical Photonics (Compulsory Elective Modules)  
Specialization - Optical Systems  
Additional Examinations

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#### Prerequisites
Only one out of the two modules "M-ETIT-100552 - Optische Systeme für Medizintechnik und Life Sciences" and "M-ETIT-103252 - Optical Systems in Medicine and Life Science" is allowed.

#### Competence Goal
**Overall Course Objectives:**
This course will allow the students to understand how the basic optical and optoelectronic principles are applied in the design of modern medical devices and routine diagnostic equipment. Besides extending and deepening their expert knowledge in engineering sciences and physics this course will provide profound insight into the applicable, the regulatory and safety and the cost requirements. This will help to be able to understand how the systems are designed to fulfill the requirements.

Furthermore, in this course the students will be introduced into case-based learning. The in-class journal club helps to make the students become more familiar with the advanced literature in the field of study. This interactive format helps to improve the students’ skills of understanding and debating current topics of active interest.

#### Teaching Targets:
The successful participation in this course enables the students to

- derive and formulate system requirements
- layout the system architecture of optical devices
- explain the underlying physical and physiological principles and mechanisms
- elaborate technical and methodological constraints and limitations

present, challenge and debate recent research results

#### Content
**Optical Systems:**
- Surgical microscope
- Scanning laser ophthalmoscope (SLO) / Confocal endomicroscope (CEM)
- Optical coherence tomography (OCT) / Optical biometer
- Refractive surgical laser
- Flow-Cytometry

**Applied Optical Technologies:**
- Magnification and illumination
- Fluorescence and diffuse reflectance imaging
- Confocal laser microscopy
- Low coherence interferometry
- fs-Laser
- Laser scattering (Mie-Therory)

**Systems Design and Engineering:**
- System architecture

**V-Model of Product Development Process**
Module grade calculation
The module grade is the grade of the written exam.

Annotation
Language English

Workload
Each credit point corresponds approximately to 30h of the student's workload. Here, the average student is expected to reach an average performance. This contains:

1. Presence during lectures (15 x 1.5 = 22.5h)
2. Preparation and wrap-up of subject matter (57.5h)

Preparation and presentation of one contribution to the in-class journal club (1 x 10h)

Recommendation
Good understanding of optics and optoelectronics.

Literature
M. Kaschke, Optical Devices in Ophthalmology and Optometry, Willey-VCH
### 2.42 Module: Optical Transmitters and Receivers [M-ETIT-100436]

**Responsible:** Prof. Dr. Wolfgang Freude  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:**  
- Specialization - Photonic Materials and Devices  
- Specialization - Optical Systems  
- Additional Examinations

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**Competence Certificate**  
Oral examination (approx. 20 minutes). The individual dates for the oral examination are offered regularly.

**Prerequisites**  
none

**Competence Goal**  
The students

- understand the peculiarities of optical communications, and how optical signals are generated, transmitted and received,  
- know about sampling, quantization and coding,  
- learn the basics about noise on reception,  
- understand the properties of a linear and a nonlinear optical fibre channel, grasp the idea of channel capacity and spectral efficiency,  
- know about various forms of modulation,  
- acquire knowledge of optical transmitter elements,  
- understand the function of optical amplifiers,  
- have a basic understanding of optical receivers,  
- know the sensitivity limits of optical systems, and  
- understand how these limits are measured.

**Content**  
The course concentrates on basic optical communication concepts and connects them with the properties of physical components. The following topics are discussed:

- Advantages and limitations of optical communication systems  
- Optical transmitters comprising lasers and modulators  
- Optical receivers comprising direct and heterodyne reception  
- Characterization of signal quality

**Module grade calculation**  
The module grade is the grade of the oral exam.

**Workload**  
Approx. 120 hours workload for the student. The amount of work is included:

- 30 h - Attendance times in lectures  
- 15 h - Exercises  
- 75 h - Preparation / revision phase

**Recommendation**  
Knowledge of the physics of the pn-junction

**Literature**  
Detailed textbook-style lecture notes can be downloaded from the IPQ lecture pages.  
Electronic version available via w.freude@kit.edu.  
### 2.43 Module: Optical Waveguides and Fibers [M-ETIT-100506]

**Responsible:** Prof. Dr.-Ing. Christian Koos  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** Specialization - Photonic Materials and Devices  
Specialization - Optical Systems  
Additional Examinations

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**Mandatory**

| T-ETIT-101945 | Optical Waveguides and Fibers | 4 CR | Koos |

**Competence Certificate**  
**Type of Examination:** Oral exam  
**Duration of Examination:** approx. 20 minutes  
**Modality of Exam:** The written exam is offered continuously upon individual appointment.

**Prerequisites**  
None

**Competence Goal**  
The students

- conceive the basic principles of light-matter-interaction and wave propagation in dielectric media and can explain the origin and the implications of the Lorentz model and of Kramers-Kronig relation,
- are able to quantitatively analyze the dispersive properties of optical media using Sellmeier relations and scientific databases,
- can explain and mathematically describe the working principle of an optical slab waveguide and the formation of guided modes,
- are able to program a mode solver for a slab waveguide in Matlab,
- are familiar with the basic principle of surface plasmon polariton propagation,
- know basic structures of planar integrated waveguides and are able to model special cases with semi-analytical approximations such as the Marcatli method or the effective-index method,
- are familiar with the basic concepts of numerical mode solvers and the associated limitations,
- are familiar with state-of-the-art waveguide technologies in integrated optics and the associated fabrication methods,
- know basic concepts of of step-index fibers, graded-index fibers and microstructured fibers,
- are able to derive and solve basic relations for step-index fibers from Maxwell's equations,
- are familiar with the concept of hybrid and linearly polarized fiber modes,
- can mathematically describe signal propagation in single-mode fibers design dispersion-compensated transmission links,
- conceive the physical origin of fiber attenuation effects,
- are familiar with state-of-the-art fiber technologies and the associated fabrication methods,
- can derive models for dielectric waveguide structures using the mode expansion method,
- conceive the principles of directional couplers, multi-mode interference couplers, and waveguide gratings,
- can mathematically describe active waveguides and waveguide bends.
Content

1. Introduction: Optical communications
2. Fundamentals of wave propagation in optics: Maxwell’s equations in optical media, wave equation and plane waves, material dispersion, Kramers-Kroig relation and Sellmeier equations, Lorentz and Drude model of refractive index, signal propagation in dispersive media.
3. Slab waveguides: Reflection from a plane dielectric boundary, slab waveguide eigenmodes, radiation modes, inter- and intramodal dispersion, metal-dielectric structures and surface plasmon polariton propagation.
4. Planar integrated waveguides: Basic structures of integrated optical waveguides, guided modes of rectangular waveguides (Marcatili method and effective-index method), basics of numerical methods for mode calculations (finite difference- and finite-element methods), waveguide technologies in integrated optics and associated fabrication methods.
5. Optical fibers: Optical fiber basics, step-index fibers (hybrid modes and LP-modes), graded-index fibers (infinitely extended parabolic profile), microstructured fibers and photonic-crystal fibers, fiber technologies and fabrication methods, signal propagation in single-mode fibers, fiber attenuation, dispersion and dispersion compensation.
6. Waveguide-based devices: Modeling of dielectric waveguide structures using mode expansion and orthogonality relations, multimode interference couplers and directional couplers, waveguide gratings, material gain and absorption in optical waveguides, bent waveguides.

Module grade calculation
The module grade is the grade of the oral exam.

There is, however, a bonus system based on the problem sets that are solved during the tutorials: During the term, 3 problem sets will be collected in the tutorial and graded without prior announcement. If for each of these sets more than 70% of the problems have been solved correctly, a bonus of 0.3 grades will be granted on the final mark of the oral exam.

Workload
Total 120 h, hereof 45 h contact hours (30 h lecture, 15 h tutorial) and 75 h homework and self-studies.

Recommendation
Solid mathematical and physical background, basic knowledge of electrodynamics

Literature
B.E.A. Saleh, M.C. Teich: Fundamentals of Photonics
G.P. Agrawal: Fiber-optic communication systems
C.-L. Chen: Foundations for guided-wave optics
Katsunari Okamoto: Fundamentals of Optical Waveguides
K. Iizuka: Elements of Photonics
2.44 Module: Optics and Photonics Lab [M-PHYS-102189]

**Responsible:** PD Dr. Michael Hetterich  
**Organisation:** KIT Department of Physics  
**Part of:** Optics & Photonics Lab

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**Mandatory**

| T-PHYS-104511 | Optics and Photonics Lab | 10 CR | Hetterich |

**Prerequisites**

none

**Competence Goal**

The students apply their theoretical knowledge in optics and photonics from the fundamental modules in practical lab work. They learn how to prepare and carry out experiments, analyse the obtained data as well as how to summarize and discuss their results in a scientific report.

The students:

- can design, build, align, and utilize optical set-ups
- are familiar with optical devices (e.g., lasers, organic light-emitting diodes, detectors, solar cells, optical fibers) and systems (e.g., machine vision, optical tweezers)
- understand interferometric methods
- know optics-related fabrication techniques
- understand various types of optical spectroscopy
- are familiar with practical applications of optical systems in physics, engineering, chemistry, and biology
- are able to scientifically analyse experimental data and critically discuss their results
- can write a scientific report

**Content**

The Optics & Photonics Lab comprises a series of different labs covering a wide range of topics from advanced laboratories of the Departments of Physics, Electrical Engineering and Information Technology, Mechanical Engineering, as well as Chemistry and Bio-Sciences.

The students will deepen and apply their theoretical knowledge from the fundamental modules by exploring different aspects of optics and photonics from optical spectroscopy (absorption and transmission spectroscopy of semiconductors, Zeeman effect, magneto-optical Kerr effect, femtosecond spectroscopy, Raman spectroscopy, …), interferometers (Fabry-Pérot, Mach–Zehnder), and fundamental quantum optics (quantum eraser) up to devices (e.g., solar cells, organic light-emitting diodes, fluorescent lamps, optical sensors), fiber optics, nanotechnology, integrated optics, and finally optical systems and their applications (e.g., cognitive automobile labs / machine vision, biological fluorescence microscopy, optical tweezers, etc.).

The number of labs in the different areas is constantly growing and evolving. Therefore, at the beginning of the first semester, a list with descriptions of the individual labs currently offered by the different faculties is provided to the students.

**Literature**

Preparation material for the labs including descriptions of the set-ups, tasks to perform, and the required background information / literature etc. are provided by the supervisors of the individual experiments beforehand.
2.45 Module: Optics and Vision in Biology [M-CHEMBIO-101906]

**Responsibility:** Prof. Dr. Martin Bastmeyer  
**Organization:** KIT Department of Chemistry and Biosciences  
**Part of:** Specialization - Biomedical Photonics (Compulsory Elective Modules)  
**Additional Examination:**

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<td>1 term</td>
<td>English</td>
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**Mandatory**

| T-CHEMBIO-105198 | Optics and Vision in Biology | 4 CR | Bastmeyer |

**Competence Certificate**

- **Type of Examination:** Written exam  
- **Duration of Examination:** 120 Minutes  
- **Modality of Exam:** The written exam is scheduled for the break after the WS. A resit exam will be offered, when needed.

**Prerequisites**
none

**Competence Goal**
The students
- understand the anatomy and optics of the vertebrate eye and its aberrations  
- comprehend retinal microanatomy and its relation to retinal computation  
- are familiar with the wiring of the retinofugal pathways in vertebrates  
- know their roles in circadian rhythm, pupillary reflex and gaze control  
- conceive the details of higher visual processing in the thalamocortical pathway  
- know how cortical processing achieves visual scene segmentation and feature binding  
- understand the psychophysics of the perception of brightness, color, shape, depth and motion  
- are acquainted with the different types of eyes in lower animals  
- can distinguish microvillated and ciliated photoreceptors  
- are able to analyse the function of compound eyes and the insect visual system  
- can conceptualize the molecular details of phototransduction in the different types of photoreceptors  
- understand the quantum bump as the signature of single-photon sensitivity  
- comprehend microbial light sensing and its influence on circadian clocks, phototropism, reproduction  
- know the underlying photoreceptors and associated proteins  
- understand how light can regulate gene expression in microorganisms  
- have grasped the mechanisms of green plant photosynthesis  
- conceive the structure and function of chloroplasts, antenna complexes and photosystems  
- have conceptualized the underlying energy transfer cascades, electron transport chain as well as the Calvin cycle of carbon fixation  
- comprehend the light path in leaves  
- know the Kautsky effect involving fluorescence and photosynthesis  
- understand the advantages and disadvantages of biofuels  
- are familiar with the principles of optogenetics as a means to genetically engineer organisms to induce light sensitivity.

**Content**

Evolution has developed abundant ways of harnessing light for the benefits of life. Through plant photosynthesis, life manifestations of all higher species are powered by solar energy. Light sensing has evolved a bewildering variety of forms ranging from light control of reproduction, germination, development in microorganisms to sophisticated visual processing in higher animals. In this course, students will develop a conceptual understanding of the overwhelming importance of light in these natural biological processes. Learning from nature might enable them in the future to generate novel ideas for technological applications of light, ranging from sustainable energy conversion to computer vision.

I. The vertebrate eye and retina  
II. Central visual pathways in vertebrates  
III. Visual processing and perception in the human cortex  
IV. Invertebrate eyes – evolution, architecture and function  
V. Phototransduction  
VI. Microbial photoreceptors and light sensing  
VII. Photosynthesis  
VIII. Optogenetics
Workload
Total 120 h, hereof 40 h contact hours and 80 h homework and self-studies.

Recommendation
Passed exam of the Adjustment Course in "Basic Molecular Cell Biology" AdjC-BMCM.
Attendance to the lecture.

Learning type
Lecture

Literature
Lecture presentations are provided in pdf-format
Neuroscience, Purves, D. et al., Sinauer, 2011
Module: Optoelectronic Components [M-ETIT-100509]

Responsible: Prof. Dr. Wolfgang Freude
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Advanced Optics & Photonics – Methods and Components

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<td>Grade to a tenth</td>
<td>Each summer term</td>
<td>1 term</td>
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Mandatory

| T-ETIT-101907 | Optoelectronic Components | 4 CR | Freude |

Competence Certificate
Type of Examination: oral exam
Duration of Examination: approx. 30 minutes
Modality of Exam: Oral examination, usually one examination day per month during the Summer and Winter terms. An extra questions-and-answers session will be held if students wish so.

Prerequisites
none

Competence Goal
Comprehending the physical layer of optical communication systems. Developing a basic understanding which enables a designer to read a device’s data sheet, to make most of its properties, and to avoid hitting its limitations.

The students
• understand the components of the physical layer of optical communication systems
• acquire the knowledge of operation principles and impairments of optical waveguides
• know the basics of laser diodes, luminescence diodes and semiconductor optical amplifiers
• understand pin-photodiodes
• know the systems’ sensitivity limits, which are caused by optical and electrical noise

Content
The course concentrates on the most basic optical communication components. Emphasis is on physical understanding, exploiting results from electromagnetic field theory, (light waveguides), solid-state physics (laser diodes, LED, and photodiodes), and communication theory (receivers, noise). The following components are discussed:
• Light waveguides: Wave propagation, slab waveguides, strip wave-guides, integrated optical waveguides, fibre waveguides
• Light sources and amplifiers: Luminescence and laser radiation, luminescent diodes, laser diodes, stationary and dynamic behavior, semiconductor optical amplifiers
• Receivers: pin photodiodes, electronic amplifiers, noise

Module grade calculation
The module grade is the grade of the oral exam.

Annotation
There are no prerequisites, but solution of the problems on the exercise sheet, which can be downloaded as homework each week, is highly recommended. Also, active participation in the problem classes and studying in learning groups are strongly advised.

Workload
total 120 h, hereof 45 h contact hours (30 h lecture, 15 h problem class), and 75 h homework and self-studies

Recommendation
Minimal background required: Calculus, differential equations, Fourier transforms and p-n junction physics.

Literature
Detailed textbook-style lecture notes as well as the presentation slides can be downloaded from the IPQ lecture pages.
Further textbooks in German (also in electronic form) can be named on request.
2.47 Module: Organic Photochemistry [M-CHEMBIO-101907]

Responsible: Prof. Dr. Hans-Achim Wagenknecht
Organisation: KIT Department of Chemistry and Biosciences

Part of: Specialization - Biomedical Photonics (Compulsory Elective Modules)

Credits: 3
Grading scale: Grade to a tenth
Recurrence: Each winter term
Duration: 1 term
Language: English
Level: 4
Version: 1

Mandatory

T-CHEMBIO-105195 Organic Photochemistry 3 CR

Prerequisites

None

Competence Goal

The students learn the principles of organic photochemistry. This includes the knowledge about the photochemical reactivity of functional groups in organic compounds, photocatalysis and applications in synthesis and bioorganic chemistry.

The students

• Can draw reaction mechanism of organic photochemical reactions
• Know the difference of direct excitation of organic functional groups vs. photocatalysis
• Know the photophysics of excitation of organic chromophores and the major decay pathways
• Can relate structure of functional groups to photochemical reactivity and organic synthesis
• Know difference of photoinduced electron transfer and energy transfer to induce organic reactions
• Know the special significance of visible light excitation

Content

1. Photophysical basics
2. Organic photochemistry
   2.1 Principles
   2.2 Photoadditions
   2.3 Photolyses
   2.4 Photoisomerization and molecular switches
3. Photocatalysis
   3.1 Flavin photocatalysis
   3.2 Template photocatalysis
   3.3 Introduction in photoredox catalysis
   3.4 Photoredoxorganocatalysis
3.5 Water splitting
4. Bioorganic photochemistry
   4.1 Photocleavable groups
   4.2 Photoaffinity labeling
   4.3 Singulet oxygen, photodynamic therapy and chemiluminescence
   4.4 Photoinduced electron transfer in DNA

Literature

### 2.48 Module: Photonic Integrated Circuit Design and Applications [M-ETIT-105914]

**Responsible:** Prof. Dr.-Ing. Christian Koos  
Prof. Dr.-Ing. Sebastian Randel

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:**  
Specialization - Photonic Materials and Devices  
Specialization - Optical Systems  
Specialization - Quantum Optics & Spectroscopy

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<td>Photonic Integrated Circuit Design and Applications</td>
<td>6 CR</td>
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**Competence Certificate**

- **Part 1 – Solutions of problem sets:** We will grade your solutions of the various problem sets and design projects. To this end, please upload your solution via the online teaching platform of your respective institution (see above) before the respective deadline. Please merge all pages into a single pdf file, and please use a scanner. Smartphone made snapshots are often illegible, and in this case your solutions cannot not be evaluated. In case there are any technical difficulties with the platforms, you may also submit your solutions by e-mail to picda@ipq.kit.edu before the respective deadline.

- **Part 2 – Presentation of one pre-assigned problem set:** At the beginning of the term, design projects will be pre-assigned to groups of participants. Each of these groups will explain their approach and results to lecturers and peer students in a short presentation (approx. 15 min), followed by approx. 10 min of public discussion with peer students and professors, and an individual private interview of each group member (approx. 10 min per person).

The overall impression is rated.

**Competence Goal**

The students understand the basic principles of photonic component design and can apply them to concrete design tasks of increasing complexity and independence, that they will solve in small groups and present to their peers. Doing so they will learn to translate theoretical knowledge gained during the lecture into actionable knowledge used to solve hands-on design tasks. In addition to design principles, students will learn how to satisfy key requirements for making photonic integrated circuits manufacturable and useable in a system environment, such as corner analysis of manufacturing tolerances, design for testability, design for manufacturability, and packaging. In short, we aim at teaching students the skills for hands-on design of manufacturable and application relevant photonic integrated circuits, preparing them to productively contribute to a design team. In addition, we will convey the most recent trends in the application of photonic integrated circuits and let students design a circuit addressing one of these application spaces, giving them a feeling for both the potential as well as the limitations of the technology, so that they may take informed decisions on what systems to integrate in the future.
Content

Lectures:

- Lecture 1: Introduction to silicon photonics
- Lecture 2: Silicon photonics – technology overview
- Lecture 3: Wave propagation in silicon photonic waveguides
- Lecture 4: Mode expansion and orthogonality
- Lecture 5: Coupled-mode theory
- Lecture 6: Selected passive devices
- Lecture 7: Modulators
- Lecture 8: Photodetectors
- Lecture 9: Optical amplifiers and lasers
- Lecture 10: Test and packaging
- Lecture 11: Optical communications
- Lecture 12: Optical metrology
- Lecture 13: Biophotonics and neurophotonics
- Lecture 14: Integrated quantum optics and optical computing

Design lab:

- Problem Set 1: Mode fields and mode expansion
- Problem Set 2: Coupling efficiency and coupled-mode theory
- Design Project A: Optical filter
- Design Project B: Optical transceiver
- Design Project C: Optical communication link

Module grade calculation

The module grade results of the assessment of the solutions of the design projects and problem sets, the presentation of one design project with discussion, and the individual oral interview. Details will be given during the lecture.

Workload

Each credit point corresponds to approximately 30 hours of work (of the students). This is based on average students who achieve an average performance. The workload includes (e.g. 2 SWS):

1. attendance in lectures an exercises: 15*2 h = 30 h
2. preparation / follow-up: 15*2 h = 30 h
3. preparation of and attendance in examination: 120 h

A total of 180 h = 6 CR

Learning type

In addition to the teaching of fundamental concepts to the extent necessary to enable students to perform practical designs, the lecture will focus from the start on a specific technology platform (silicon-on-insulator) in which the students will solve design problems of increasing complexity with the design suite Lumerical. As the final hands-on problem, students will design an entire photonic subsystem for an application of their choice, leaving free room for creative thinking and self-driven work. Since each group of students will present one of the solved designed problems to their peers, students will get exposed to solutions found for and practical problems encountered in a variety of design tasks, providing them with a wider experience base to draw on for future design.

Since the class will be taught by lecturers from several Universities, all lectures will be streamed live (with the possibility to interact and to ask questions) and made available online. Design tasks will be performed with the Design Suite Lumerical, for which introductory videos will be made available. An online forum will be provided to allow students to ask questions offline to the lecturers as well as to interact with each other, inside and across Universities.
2.49 Module: Plastic Electronics / Polymerelectronics [M-ETIT-100475]

Responsible: Prof. Dr. Ulrich Lemmer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Specialization - Photonic Materials and Devices
Specialization - Optical Systems
Specialization - Solar Energy (Compulsory Elective Modules)
Additional Examinations

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<td>Each winter term</td>
<td>1 term</td>
<td>German/English</td>
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</table>

Mandatory

| T-ETIT-100763 | Plastic Electronics / Polymerelectronics | 3 CR | Lemmer |

Competence Certificate
Type of Examination: oral exam (approx. 20 minutes)

Prerequisites
none

Competence Goal
The students:

- understand the electronic and optical characteristics of organic semiconductors
- know the fundamental differences between organic and conventional inorganic semiconductors.
- have basic knowledge of manufacturing and processing technologies,
- have knowledge of organic light-emitting diodes, organic solar cells and photodiodes, organic field-effect transistors and organic lasers.
- have an overview of the possible applications, markets and development lines for these components.
- are able to work in multidisciplinary teams with engineers, chemists and physicists

Content

1. Introduction
2. Optoelectronic properties of organic semiconductors
3. Organic light emitting diodes (OLEDs)
4. Applications in Lighting and Displays
5. Organic FETs
6. Organic photodetectors and solar cells
7. Lasers and integrated optics

Module grade calculation
The module grade is the grade of the written exam.

Annotation
Lecture and exercises are held as required in German or English.

Workload
1. lecture: 21 h
2. recapitulation and self-studie: 42 h
3. preparation of examination: 27 h

Recommendation
Knowledge of semiconductor components

Literature
The corresponding documents are available online in the VAB (https://studium.kit.edu/)
Module: Quantum Optics [M-PHYS-103093]

**Responsible:** Prof. Dr. Carsten Rockstuhl

**Organisation:** KIT Department of Physics

**Part of:**
- Specialization - Photonic Materials and Devices
- Specialization - Optical Systems
- Specialization - Quantum Optics & Spectroscopy

**Additional Examinations**

**Credits**
- 6

**Grading scale**
- Grade to a tenth

**Recurrence**
- Each winter term

**Duration**
- 1 term

**Language**
- English

**Level**
- 4

**Version**
- 1

**Mandatory**

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<td>Each winter term</td>
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**Competence Goal**

The students of quantum optics comprehend the physics of quantum optical phenomena, the necessary theoretical means for their description, and the application of quantum optical resources in different applications and technologies. They learn how to express quantum optical phenomena in a mathematical language and can apply routinely different techniques to study quantum optical phenomena in specific situations. They are trained to solve basic problems in quantum optics.

The students

- learn about the quantisation of electromagnetic fields,
- understand the details of different quantum states of light,
- get an overview over experiments that were important in the development of quantum optics,
- develop an understanding for the quantum optical description of the first and second order coherence functions, and
- understand and can routinely apply different means to describe the interaction of quantum states of light with quantum emitters.

**Content**

- Quantization of the electromagnetic field
- Various quantum states of light fields: optical photon-number, coherent, squeezed, Schrödinger’s cat states
- Classical and quantum coherence theory: photon bunching and antibunching
- Quantum description of optical interferometry: Mach-Zehnder interferometer with photons
- General description of open quantum system: master equation, Heisenberg-Langevin, and stochastic approaches
- Optical test of quantum mechanics: Hong-Ou-Mandel, quantum eraser, and Bell’s theorem experiments
- Interaction of a single atom with a classical field and quantum field
- From Rabi model to Jaynes-Cummings model: the most simplest model to describe the light-matter interaction
- Quantum master equation approach: description of finite life time of atoms
- Weak and strong couplings (spontaneous emission, Purcell effect, resonance fluorescence, lasers, and Rabi oscillation)
- Interaction of an ensemble of atoms with a quantum field (Dicke and Tavis-Cummings models, and superradiance)
- Quantum optical applications (quantum cryptography, quantum teleportation, quantum metrology, etc.)

**Literature**

- C. Gerry and P. Knight, *Introductory Quantum Optics*.
- M. O. Scully and M. S. Zubairy, *Quantum Optics*.
- M. Fox, *Quantum Optics: An Introduction*.
- D.F. Walls and G. J. Milburn, *Quantum Optics*.
- W. Schleich, *Quantum Optics in Phase Space*. 

Optics and Photonics Master 20151 (Master of Science (M.Sc.))
Module Handbook as of 24/10/2022
2.51 Module: Quantum Optics at the Nano Scale: Basics and Applications, with Exercises [M-PHYS-104092]

Responsible: Prof. Dr. David Hunger
Organisation: KIT Department of Physics
Part of: Specialization - Quantum Optics & Spectroscopy
Additional Examinations

<table>
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<th>Credits</th>
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Mandatory
T-PHYS-108478 Quantum Optics at the Nano Scale: Basics and Applications, with Exercises 8 CR Hunger

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104094 - Quantum Optics at the Nano Scale: Basics and Applications, without Exercises must not have been started.

Competence Goal
Students gain knowledge about the fundamentals in the field of quantum- and nano optics and learn about basic concepts and examples of optical quantum systems. This is intended to enable participants to follow current research in the field. The Tutorial is designed as a journal club, where selected publications will be presented by students. Students learn how to become familiar with current research topics, how to interpret research results based on the concepts presented in the lecture, and how to present scientific results.

Content
- Fundamentals of quantized light fields and light-matter interactions
- Micro- and nano-optical devices
- Dipole emission in structured environments
- Solid state quantum emitters
- Optical readout of single spins
- Quantum communication
- Quantum networks
- Quantum sensing
- Quantum computing

Recommendation
Basic knowledge in classical electromagnetism and optics, quantum mechanics, atomic physics; quantum optics is beneficial but not mandatory

Literature
- Principles of Nano-Optics, Novotny, Hecht, Cambridge University Press
- Fundamentals of Photonics, Saleh, Teich
- research articles (will be sent around)
### Module: Quantum Optics at the Nano Scale: Basics and Applications, without Exercises [M-PHYS-104094]

**Responsible:** Prof. Dr. David Hunger  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
KIT Department of Physics  
**Part of:** Specialization - Quantum Optics & Spectroscopy  
Additional Examinations

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**Competence Certificate**  
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

**Prerequisites**  
none

**Modeled Conditions**  
The following conditions have to be fulfilled:

1. The module M-PHYS-104092 - Quantum Optics at the Nano Scale: Basics and Applications, with Exercises must not have been started.

**Competence Goal**  
Students gain knowledge about the fundamentals in the field of quantum- and nano optics and learn about basic concepts and examples of optical quantum systems. This is intended to enable participants to follow current research in the field.

**Content**

- Fundamentals of quantized light fields and light-matter interactions  
- Micro- and nanooptical devices  
- Dipole emission in structured environments  
- Solid state quantum emitters  
- Optical readout of single spins  
- Quantum communication  
- Quantum networks  
- Quantum sensing  
- Quantum computing

**Recommendation**  
Basic knowledge in classical electromagnetism and optics, quantum mechanics, atomic physics; quantum optics is beneficial but not mandatory

**Literature**

- Principles of Nano-Optics, Novotny, Hecht, Cambridge University Press  
- Fundamentals of Photonics, Saleh, Teich  
- research articles (will be sent around)
2.53 Module: Research Project [M-PHYS-102194]

**Responsible:** Prof. Dr. Heinz Kalt

**Organisation:** KIT Department of Physics

**Part of:**
- Specialization - Photonic Materials and Devices
- Specialization - Biomedical Photonics (Compulsory Elective Modules)
- Specialization - Optical Systems
- Specialization - Solar Energy (Compulsory Elective Modules)
- Specialization - Quantum Optics & Spectroscopy

**Additional Examinations**

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**Mandatory**

| T-PHYS-103632 | Research Project | 4 CR | Kalt |

**Prerequisites**

none

**Competence Goal**
The Research Project augments the theoretical knowledge acquired in the elective lecture courses by application to hands-on research in the respective KSOP research area. Hereby the student will also explore possible topics for the subsequent master thesis.

The students

- get in-depth insight into a special research topic
- get hands-on experience in experimental and/or theoretical techniques
- learn how to obtain and evaluate relevant scientific literature
- get first experience on how to plan and organize a research project
- learn how to write a scientific report has the possibility to explore a topic for her/his Master’s Thesis

**Content**
The 3rd semester Research Project is optional, but highly recommended for students not working in a KSOP institute as research assistants. Accordingly, the topics of the Research Projects are provided by the KSOP PIs on an individual basis. The projects are supposed to complement the set of elective lecture courses within the specialization area of the student.

The topics of the Research Projects are constantly adapted to the current research within KSOP.

**Literature**

Literature is provided by the supervisors of the individual projects.
2.54 Module: Seminar Course [M-PHYS-102195]

**Responsible:** Prof. Dr. David Hunger  
**Organisation:** KIT Department of Physics  
**Part of:** Seminar Course (Research Topics in Optics & Photonics)

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**Mandatory**

| T-PHYS-104516 | Seminar Course | 4 CR | Hunger |

**Prerequisites**

none

**Competence Goal**

This common seminar gives an overview over the research in optics and photonics at KSOP. It provides for the students a balance between their specialization and an indispensable broad background. Furthermore, the students will learn how to present a scientific topic to a peer audience.

The students

- acquire skills in presentation techniques like Power Point
- learn how to present a scientific topic to a peer audience
- learn how to defend a topic in a scientific discussion
- can improve their presentation skills due to feedback from the audience
- get in-depth insight into a special research topic
- get a broad background on topical research in optics & photonics

**Content**

The Seminar Course comprises a series of talks covering a wide range of topics from the research of the KSOP PI groups. The students are split into two groups of about 20 students each. Every student gives a presentation on a topic chosen from a list provided on the KSOP sharepoint. Typical topics are "Photonic Waveguides", "Image Stitching", "Optical Frequency Multiplexing", "Surface Polaritons", "Random Lasing", "Digital Holography", "Imaging of Living Cells", "Organic Solar Cells", "Quantum Computer", "Optical Tweezers", "Biophotonic Sensors", "Optical Nanoantennas", and more. The preparation of the talks is assisted by researchers from the KSOP PI groups.

The seminar topics are constantly adapted to the current research within KSOP.

**Literature**

Literature is provided by the supervisors of the individual talks beforehand.
M 2.55 Module: Solar Energy [M-ETIT-100524]

Responsible: Prof. Dr. Bryce Sydney Richards
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Specialization - Photonic Materials and Devices
              Specialization - Solar Energy (Compulsory Modules)
Additional Examinations

Credits 6
Grading scale Grade to a tenth
Recurrence Each winter term
Duration 1 term
Language English
Level 4
Version 1

Mandatory

| T-ETIT-100774 | Solar Energy | 6 CR | Richards |

Competence Certificate
Type of Examination: written exam
Duration of Examination: 120 Minutes
Modality of Exam: One written exam at the end of each semester.

Prerequisites
Students not allowed to take either of the following modules in addition to this one: „Solarenergie“ (M-ETIT-100476) and „Photovoltaik“ (M-ETIT-100513).

Competence Goal
The students:
• understand the basic working principle of pn-junction solar cells,
• learn about the different kinds of solar cells (crystalline and amorphous silicon, CIGS, Cadmium telluride, organic, dye-sensitized solar cells, etc.),
• get an overview over upcoming third-generation photovoltaic concepts,
• receive information on photovoltaic modules and module fabrication,
• develop an understanding of solar cell integration and feeding the electrical power to the grid,
• get insight into solar concentration and tandem solar cells for highly efficient energy conversion,
• compare photovoltaic energy harvesting with solar thermal technologies
• understand the environmental impact of solar energy technologies.

Die Studentinnen und Studenten können in englischer Fachsprache sehr gut kommunizieren.

Content
I. Introduction: The Sun
II. Semiconductor fundamentals
III. Solar cell working principle
IV. First Generation solar cells: silicon wafer based
V. Second Generation solar cells: thin films of amorphous silicon, copper indium gallium diselenide, cadmium telluride, organic photovoltaics and dye sensitized solar cells
V. Third Generation Photovoltaics: high-efficiency device concepts incl. tandem solar cells
VI. Modules and system integration
VII. Cell and module characterization techniques
VIII. Economics, energy pay-back time, environmental impact
IX. Other solar energy harvesting processes, incl. thermal and solar fuels
X. Excursion

Module grade calculation
The module grade is the grade of the written exam.

Workload
Total 180 h, thereof 60h contact hours (45h lecture, 15h problems class), and 120h homework and self-studies
Recommendation
Knowledge of optoelectronics is a prerequisite, e.g. M-ETIT-100480 – Optoelektronik.

Literature
P. Würfel: Physics of Solar Cells
V. Quaschning: Renewable Energy Systems
2.56 Module: Solar Thermal Energy Systems [M-MACH-101924]

Responsible: apl. Prof. Dr. Ron Dagan
Organisation: KIT Department of Mechanical Engineering

Part of: Specialization - Solar Energy (Compulsory Elective Modules) Additional Examinations

Credits 4  Grading scale Grade to a tenth  Recurrence Each winter term  Duration 1 term  Language English  Level 4  Version 3

Mandatory
T-MACH-106493 Solar Thermal Energy Systems  4 CR Dagan

Competence Certificate
oral exam of about 30 minutes

Prerequisites
None

Competence Goal
The students
get familiar with the global energy demand and the role of renewable energies
learn about improved designs for using efficiently the potential of solar energy
gain basic understanding of the main thermal hydraulic phenomena which support the work on future innovative applications
will be able to evaluate quantitatively various aspects of the thermal solar systems

Content
I. Introduction to solar energy: Energy resources, consumption and costs
II. The sun as an energy resource:
   Structure of the sun, Black body radiation, solar constant, solar spectral distribution
   Sun-Earth geometrical relationship
III. Passive and active solar thermal applications.
IV. Fundamentals of thermodynamics and heat transfer
V. Solar thermal systems - solar collector-types, concentrating collectors, solar towers. Heat losses and efficiency
VII. Energy storage
The course deals with fundamental aspects of solar energy. Starting from a global energy panorama the course deals with the sun as a thermal energy source. In this context, basic issues such as the sun's structure, blackbody radiation and solar–earth geometrical relationship are discussed. In the next part, the lectures cover passive and active thermal applications and review various solar collector types including concentrating collectors and solar towers and the concept of solar tracking. Further, the collector design parameters determination is elaborated, leading to improved efficiency. This topic is augmented by a review of the main laws of thermodynamics and relevant heat transfer mechanisms.
The course ends with an overview on energy storage concepts which enhance practically the benefits of solar thermal energy systems.

Workload
Total 90 h, hereof 30 h contact hours and 60 h homework and self-studies

Learning type
Lecture, tutorial

Literature
Foster, Ghassemi, cota; Solar Energy
Duffie and Beckman; Solar engineering of thermal processes
Holman; Heat transfer
Heinzel; script to solar thermal energy (in German)
2.57 Module: Solid-State Optics [M-PHYS-102408]

Responsible: PD Dr. Michael Hetterich
Prof. Dr. Heinz Kalt

Organisation: KIT Department of Physics

Part of:
- Specialization - Photonic Materials and Devices
- Specialization - Solar Energy (Compulsory Elective Modules)
- Specialization - Quantum Optics & Spectroscopy

Additional Examinations

Credits: 8
Grading scale: Grade to a tenth
Recurrence: Each winter term
Duration: 1 term
Language: English
Level: 4
Version: 1

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Competence Certificate

Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites

none

Competence Goal

The students

- know the basic interaction processes between light and matter and are familiar with the polariton concept
- can explain the optical properties of insulators, semiconductors (including quantum structures) and metals
- comprehend the concept of the dielectric function and can utilize it to calculate relevant optical quantities
- are familiar with the classical Drude-Lorentz model and its implications for the optical properties of solids
- understand the relation between classical and quantum mechanical models for the dielectric function as well as the importance of the Kramers Kronig relations
- can explain near-band-edge optical spectra of semiconductors and insulators based on the concepts of joint density of states, oscillator strength, as well as excitonic effects
- are familiar with common experimental techniques of optical spectroscopy
- understand the origin of different optical nonlinearities and high-excitation effects as well as their mathematical description, their experimental realization and their applications
- comprehend the basics of group theory and can apply it to solid state optics

Content

Maxwell's equations, refractive index, dispersion, dielectric function, extinction, absorption, reflection, continuity conditions at interfaces, anisotropic media and layered systems, Drude–Lorentz model, reststrahlen bands, Bloch states and band structure, perturbation theory of light–matter interaction, band to band transitions, joint density of states, van Hove singularities, phonon and exciton polaritons, plasmons, metals, semiconductor heterostructures, low-dimensional systems, group theory and selection rules, nonlinear optics, high-excitation effects in semiconductors, measurement of optical functions: Fourier spectroscopy, ellipsometry, modulation spectroscopy, photoluminescence, reflectometry, absorptivity.

Workload

240 hours, consisting of attendance time (60 hours) and follow-up work incl. preparation of the exam (180 hours)

Recommendation

Basic knowledge of solid-state physics and quantum mechanics is expected.

Literature

- H. Kalt, C. Klingshirn: Semiconductor Optics
- F. Wooten: Optical Properties of Solids
- P.K. Basu: Theory of optical processes in semiconductors
- H. Ibach and H. Lüth: Solid-State Physics
Module: Spectroscopic Methods [M-CHEMBIO-101900]

**Responsible:** Prof. Dr. Manfred Kappes
appl. Prof. Dr. Andreas-Neil Unterreiner

**Organisation:** KIT Department of Chemistry and Biosciences

**Part of:** Advanced Optics & Photonics – Methods and Components

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<td>English</td>
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**Prerequisites**

None

**Competence Goal**

The students get introduced into various methodologies of molecular spectroscopy in frequency and time domain. Due to different basic knowledge they first get acquainted with the microscopic physical background, but later on with the interpretation of the respective optical spectra and application in various fields. The students enhance their knowledge on spectroscopic equipment and optical components for the respective spectroscopic and/or microscopic technique. The students

- know the quantum mechanical basis of molecular rotational, vibrational and electronic spectroscopy
- conceive a microscopic understanding of optical excitation/deexcitation processes in molecules, i.e. light-matter interaction
- understand the interplay between spectroscopic method, experimental design and required optical components
- are familiar with sample preparation techniques in molecular spectroscopy (supersonic expansion, ion traps, soft-landing on surfaces, matrix-isolation)
- learn time scales of various molecular motions (especially rotation and vibration) before and during chemical/biochemical reactions
- will get in touch with timescales and frequencies of molecular properties and experience their interconnection are introduced into linear and nonlinear molecular spectroscopy including two-dimensional techniques such as two-dimensional vibrational spectroscopy

**Content**

I. Introduction to electronic spectroscopy (Born Oppenheimer approximation, Franck-Condon factor, relaxation processes)
II. Fluorescence spectroscopy and microscopy (Jablonski diagram, Kasha’s rule, Vavilov’s rule, kinetic and lifetime considerations, Stokes shift, Lippert equation, fluorescence anisotropy; confocal fluorescence microscopy, advanced microscopic methods, e.g. STED)
III. Well-defined sample techniques: spectroscopy in molecular beams, in ion traps and on surfaces (laser-induced fluorescence, cavity ringdown spectroscopy, matrix-isolation spectroscopy, photoelectron spectroscopy)
IV. Introduction to time-dependent phenomenon including time-dependent perturbation theory for selection rules, spectral line shape
V. Generation and characterization of tunable laser pulses with pulse durations well below 1 picosecond
VI. Various methods of pump-probe spectroscopy covering the spectral range from the microwave to the X-ray regime

**Literature**

Demtröder: Laser Spectroscopy, Rullière: Femtosecond Laser Pulses, Atkins: Molecular Quantum Mechanics, various review articles
2.59 Module: Systems and Software Engineering [M-ETIT-100537]

Responsible: Prof. Dr.-Ing. Eric Sax
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Specialization - Optical Systems

Additional Examinations

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Competence Certificate
Written exam, approx. 120 minutes. (§4 (2), 1 SPO).

Prerequisites
none

Competence Goal
The students:

- know the most important Life Cycle and process models (including V-Model and agile methods).
- are capable of choosing a suitable method to design and evaluate complex systems.
- know the most important diagram types of hardware and software modeling languages and can design such diagrams from characterization of an application area.
- know the basic methods for quality assurance, which are needed during project development. They know the different test phases of a project and can evaluate the reliability of a system.
- They are familiar with the issues of functional safety and the standards of process evaluation.

Content
Major topics are techniques and methods for the design of complex electric, electronic and electronic programmable systems with software fragments and hardware fragments. The competences of the course comprise comprehensive knowledge and goal-oriented usage of state of the art modeling techniques, development processes, description techniques as well as specification languages.

Module grade calculation
Grades result from the written examination.

Workload
Each credit point (LP, Credit Points) corresponds around 25-30h of work effort of the student. Hereby we assume an average student with average performance. The workload is covered by:
1. Participating in lectures, tutorials and practical labs.
2. Preparing and wrap up of the above named units.
3. Exam preparation and presence.

Recommendation
Participation in the lectures Digital System Design (23615) and Information Technology (23622) is advised.
2.60 Module: Theoretical Nanooptics [M-PHYS-102295]

Responsible: Prof. Dr. Carsten Rockstuhl
Organisation: KIT Department of Physics
Part of:
- Specialization - Photonic Materials and Devices
- Specialization - Optical Systems
- Specialization - Solar Energy (Compulsory Elective Modules)

Additional Examinations

Credits 6
Grading scale Grade to a tenth
Recurrence Irregular
Duration 1 term
Language English
Level 4
Version 1

Mandatory
T-PHYS-104587 Theoretical Nanooptics 6 CR Rockstuhl

Competence Certificate
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Competence Goal
The properties of light at the nanoscale can be controlled by various means. The aim of this lecture is to familiarize the students with the different possibilities that rely on nanostructured dielectric or metallic materials and to outline on solid mathematical grounds the analytical description of observable effects. The lecture is meant as a complementary source of education to experimental lecture. It shall provide the students with the necessary skills to work themselves in the field of theoretical nanooptics.

Content

- Dispersion relation to describe light in extended systems such as free space, interfaces, planar waveguides and waveguides with complicated geometrical cross sections.
- Description of the interaction of light with isolated objects such as spheres, cylinders, ellipsoids and prolates and oblates.
- Properties of plasmonic nanoparticles and the ability to tune their properties
- Notion of optical antennas and the discussion of their basic characteristics
- Description of the dynamics of wave propagation by perturbed eigenstates, i.e. coupled mode theory. Application to optical waveguide arrays.
- Discussion of metamaterials (unit cells, homogenization, light propagation, applications)
- Transformation optics
- Analytical modeling and phenomenological tools to describe nanooptical systems

Workload
180 hours composed of active time (45), wrap-up of the lecture incl. preparation of the examination and the exercises (135)

Recommendation
Solid mathematical background, good knowledge of classical electromagnetism and theoretical optics.

Literature
- L. Novotny and B. Hecht, Principle of Nano-Optics, Cambridge
- S. A. Maier, Plasmonics, Springer
Module: Theoretical Optics [M-PHYS-102280]

**Responsible:** Prof. Dr. Carsten Rockstuhl

**Organisation:** KIT Department of Physics

**Part of:** Advanced Optics & Photonics – Theory and Materials

**Credits:** 4

**Grading scale:** Grade to a tenth

**Recurrence:** Each summer term

**Duration:** 1 term

**Language:** English

**Level:** 4

**Version:** 1

### Prerequisites

None

### Competence Goal

The students deepen their knowledge about the theory and the mathematical tools in optics and photonics. They learn how to apply these tools to describe fundamental phenomena and how to predict observable quantities that reflect the actual physics from the theory by way of a corresponding purposeful mathematical analyses. They learn how to solve problems of both, interpretative and predictive nature with regards to model systems and real life situations.

The students:

- understand the theoretical basis and physical content of the classical Maxwell equations and the quantum description of light
- know how to formulate and discuss optical properties in mathematical form
- are able to utilize advanced mathematical tools for the quantitative description of wave propagation in various settings such as anisotropic materials and diffractive systems
- are able to quantify and utilize basic phenomena of coherence
- are familiar with the quantitative analysis of classical wave propagation in basic devices and systems
- appreciate the limitations of the classical description of light and the novel phenomena associated with systems for which a quantum description is required
- are able to quantitatively analyse simple quantum optical devices

### Content

- Review of Electromagnetism (Maxwell’s Equations, Stress Tensor, Material Properties, Kramers-Kronig Relation, Wave Propagation, Poynting’s Theorem)
- Crystal Optics (Polarization, Anisotropic Media, Fresnel Equation, Applications)
- Classical Coherence Theory (Elementary Coherence Phenomena, Theory of Stochastic Processes, Correlation Functions)
- Quantum Optics and Quantum Optical Coherence Theory (Review of Quantum Mechanics, Quantization of the EM Field, Quantum Coherence Functions)

### Recommendation

Solid mathematical background, good knowledge of classical electromagnetism and basic knowledge of quantum mechanics.

### Literature

- "Classical Electrodynamics" John David Jackson
- "Theoretical Optics: An Introduction" Hartmann Römer
- "Introduction to Fourier Optics" Joseph W. Goodman
- "Introduction to the Theory of Coherence and Polarization of Light" Emil Wolf
- "The Quantum Theory of Light" Rodney Loudon
2.62 Module: X-Ray Optics [M-MACH-101920]

**Responsible:** Dr. Arndt Last  
**Organisation:** KIT Department of Mechanical Engineering  
**Part of:** Specialization - Photonic Materials and Devices  
Specialization - Optical Systems  
**Credits:** 3  
**Grading scale:** Grade to a tenth  
**Recurrence:** Each term  
**Duration:** 1 term  
**Language:** English  
**Level:** 4  
**Version:** 1

### Mandatory

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<th>X-Ray Optics</th>
<th>3 CR</th>
<th>Last</th>
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**Competence Certificate**  
A performance assessment is obligatory and can be oral, a written exam, or of another kind.

**Prerequisites**  
none

**Competence Goal**  
The students

- know the importance of X-ray optics in science and material analysis
- can describe the basic phenomena of X-ray generation, propagation and detection
- can calculate the optical path X-rays will follow
- are familiar with different types of X-ray optics
- can decide what X-ray optical component is suited best for what application
- comprehend the concepts of refraction, reflection, diffraction and absorption and are aware of their importance in X-ray optics
- know the differences between ray tracing and wave propagation methods and can assess what method is applicable in what case
- conceive manufacturing methods of X-ray optics
- know how to characterize X-ray optical components

**Content**

I. Introduction: Application of X-ray optics  
II. X-ray generation  
III. Propagation of X-rays in matter  
IV. X-ray detection  
V. Types of X-ray optics: reflecting, refracting, diffracting, absorbing  
VI. Characteristics of X-ray optics  
VII. Methods to simulate X-ray optics (ray tracing, wave propagation)  
VIII. Manufacturing of X-ray optics  
IX. Characterization of X-ray optics

**Literature**

A. Erko, M. Idir, Th. Krist and A. G. Michette (editors), Modern Developments in X-Ray and Neutron Optics  
www.x-ray-optics.com
3.1 Course: Adaptive Optics [T-ETIT-107644]

**Responsible:** Prof. Dr. Ulrich Lemmer

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** M-ETIT-103802 - Adaptive Optics

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**Exams**

| ST 2022    | 7313724 | Adaptive Optics | Lemmer, Gladysz |

**Competence Certificate**

Type of Examination: Oral examination

Duration of Examination: approx. 30 Minutes

Modality of Exam: The oral exam will be scheduled during the semester break.

**Prerequisites**

None.

**Recommendation**

Basic knowledge of statistics.
### 3.2 Course: Advanced Inorganic Materials [T-CHEMBIO-103591]

**Organisation:** KIT Department of Chemistry and Biosciences  
**Part of:** M-CHEMBIO-101901 - Advanced Inorganic Materials

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**Prerequisites**

acc. to module catalogue
3.3 Course: Advanced Molecular Cell Biology [T-CHEMBIO-105196]

**Responsible:** Dr. Franco Weth

**Organisation:** KIT Department of Chemistry and Biosciences

**Part of:** M-CHEMBIO-101904 - Advanced Molecular Cell Biology

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**Competence Certificate**
Examination: 120min (written) or approx. 45min (oral)

**Prerequisites**
none

**Recommendation**
Passed exam of the Adjustment Course in “Basic Molecular Cell Biology”.

**Annotation**
Advanced textbook or review articles will be announced on a weekly basis. They have to be read by all participants. The contents will be discussed in the class sessions. Each class session is chaired by one participant and all participants have to contribute a sub-chapter / figure per session. For the problems class, exercise sheets will be handed out and participants have to be prepared to present their solutions.
### 3.4 Course: Automotive Vision [T-MACH-105218]

**Responsible:** Dr. Martin Lauer  
Prof. Dr.-Ing. Christoph Stiller  

**Organisation:** KIT Department of Mechanical Engineering  

**Part of:** M-MACH-102693 - Automotive Vision  

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</table>

**Competence Certificate**

- Type of Examination: written exam  
- Duration of Examination: 60 minutes  

**Prerequisites**

- none

Below you will find excerpts from events related to this course:

#### Lecture (V)

**Automotive Vision**  
2138340, SS 2022, 3 SWS, Language: English, Open in study portal

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**Content**

**Lernziele (EN):**  
Machine perception and interpretation of the environment for the basis for the generation of intelligent behaviour. Especially visual perception opens the door to novel automotive applications. First driver assistance systems can already improve safety, comfort and efficiency in vehicles. Yet, several decades of research will be required to achieve an automated behaviour with a performance equivalent to a human operator. The lecture addresses students in mechanical engineering and related subjects who intend to get an interdisciplinary knowledge in a state-of-the-art technical domain. Machine vision, vehicle kinematics and advanced information processing techniques are presented to provide a broad overview on ‘seeing vehicles’. Application examples from cutting-edge and future driver assistance systems illustrate the discussed subjects.

**Lehrinhalt (EN):**

1. Driver assistance systems  
2. Binocular vision  
3. Feature point methods  
4. Optical flow/tracking in images  
5. Tracking and state estimation  
6. Self-localization and mapping  
7. Lane recognition  
8. Behavior recognition  

Nachweis: Written examination 60 minutes  
Arbeitsaufwand (EN): 120 hours

**Literature**

Foliensatz zur Veranstaltung wird als kostenlose pdf-Datei bereitgestellt. Weitere Empfehlungen werden in der Vorlesung bekannt gegeben.
## 3.5 Course: Basic Molecular Cell Biology [T-CHEMBIO-105199]

**Responsible:** Dr. Franco Weth  
**Organisation:** KIT Department of Chemistry and Biosciences  
**Part of:** M-CHEMBIO-101903 - Basic Molecular Cell Biology

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### Events

| ST 2022  | 7148 | Basic Molecular Cell Biology KSOP | 2 SWS | Lecture / Weth, Bastmeyer |

### Exams

| ST 2022 | 71KSOP-105199 | Basic Molecular Cell Biology | Weth |

**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

**Competence Certificate**

The written exam over 120 Minutes is scheduled for the beginning of the break after the SS. A resit exam is offered at the end of the break.

**Prerequisites**

none

**Recommendation**

Basic knowledge in General Chemistry
3.6 Course: Business Innovation in Optics and Photonics [T-ETIT-104572]

**Responsible:** Prof. Dr. Werner Nahm  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-101834 - Business Innovation in Optics and Photonics

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**Exams**

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*Legend:* 🖥 Online, 🤴 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

**Competence Certificate**

Type of Examination: examination of another type  
Duration of Examination: 4 group presentations à 20 minutes (approx.)  
Modality of Exam: The exam consists of four group presentations. 2nd day: Technology Presentation. 3rd day: Development plan presentation. 4th day: Business Canvas presentation. Final presentation at Zeiss visit: Business pitch

**Prerequisites**

Good knowledge in optics & photonics.
### 3.7 Course: Computational Photonics, without ext. Exercises [T-PHYS-106131]

<table>
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<tr>
<th>Responsible</th>
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### 3.8 Course: Digital Signal Processing in Optical Communications – with Practical Exercises [T-ETIT-106852]

**Responsible:** Prof. Dr.-Ing. Sebastian Randel  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-103450 - Digital Signal Processing in Optical Communications – with Practical Exercises

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**Competence Certificate**  
The exercise sheets and the oral questionnaire are used to rate other types of examinations. The overall impression is assessed. Duration about 20 minutes.

**Prerequisites**  
Basic knowledge of optical communication systems. Proven, for example, by completing one of the modules "Optical Networks and Systems-ONS", "Optoelectronic Components -OC", or "Optical Transmitters and Receivers - OTR.

**Recommendation**  
Knowledge of the basics of optical communication technology and digital signal processing is helpful.
### 3.9 Course: Electric Power Generation and Power Grid [T-ETIT-103608]

**Responsible:** Dr.-Ing. Bernd Hoferer  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-101917 - Electric Power Generation and Power Grid

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**Prerequisites**

none
### 3.10 Course: Electromagnetics and Numerical Calculation of Fields [T-ETIT-100640]

**Responsible:** Prof. Dr.-Ing. Thomas Zwick  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-100386 - Electromagnetics and Numerical Calculation of Fields

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#### Exams

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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**

Success control is carried out in the form of a written test of 120 minutes.

**Prerequisites**

none

**Recommendation**

Fundamentals of electromagnetic field theory.
### 3.11 Course: Fabrication and Characterisation of Optoelectronic Devices [T-ETIT-103613]

**Responsible:**  Prof. Dr. Bryce Sydney Richards  
**Organisation:**  KIT Department of Electrical Engineering and Information Technology  
**Part of:**  M-ETIT-101919 - Fabrication and Characterisation of Optoelectronic Devices

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**Legend:**  🖥 Online,  🧩 Blended (On-Site/Online),  🗣 On-Site,  🗝 Cancelled

**Prerequisites**

none
3 COURSES

Course: Field Propagation and Coherence [T-ETIT-100976]

3.12 Course: Field Propagation and Coherence [T-ETIT-100976]

 Responsible: Prof. Dr. Wolfgang Freude
 Organisation: KIT Department of Electrical Engineering and Information Technology
 Part of: M-ETIT-100566 - Field Propagation and Coherence

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<td>2 SWS</td>
<td>Lecture / Online</td>
<td>Freude, Maier, Reichenbacher</td>
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Exams

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Prerequisites

none
### 3.13 Course: Fundamentals of Optics and Photonics [T-PHYS-103628]

**Responsible:** Prof. Dr. David Hunger  
**Organisation:** KIT Department of Physics  
**Part of:** M-PHYS-101927 - Fundamentals of Optics and Photonics

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**Legend:** 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Prerequisites**

Successfull participation in the exercises

**Modeled Conditions**

The following conditions have to be fulfilled:

1. The course T-PHYS-103630 - Fundamentals of Optics and Photonics - Unit must have been passed.
### 3.14 Course: Fundamentals of Optics and Photonics - Unit [T-PHYS-103630]

**Responsible:** Prof. Dr. David Hunger  
**Organisation:** KIT Department of Physics  
**Part of:** M-PHYS-101927 - Fundamentals of Optics and Photonics

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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣️ On-Site, ⌚️ Cancelled

**Prerequisites**

none
3.15 Course: German at ID A1.1 [T-IDSCHOOLS-109427]

Responsible: Katrina Pangritz
Organisation: Part of: M-IDSCHOOLS-104603 - German at ID A1.1

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Exams

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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

Competence Certificate

The results will be assessed in the form of a 90-minute written examination pursuant to § 4 Para. 2 No. 1 SPO Master "Optics & Photonics".

The module mark is the mark of the written examination.

Prerequisites

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester
2. passing 2 out of 3 tests written during the semester as a performance test
3. submission of 2 out of 3 written homework assignments (texts) during the semester

Recommendation

Strong motivation for self-study
3.16 Course: German at ID A1.2 [T-IDSCHOOLS-109201]

**Responsible:** Katrina Pangritz

**Organisation:**

Part of: M-IDSCHOOLS-104604 - German at ID A1.2

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**Exams**

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Legend: 🖥 Online, 🌟 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

**Competence Certificate**

The results will be assessed in the form of a 90-minute written examination pursuant to § 4 Para. 2 No. 1 SPO Master "Optics & Photonics".

The module mark is the mark of the written examination.

**Prerequisites**

Successful completion of German level A1.1

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester
2. passing 2 out of 3 tests written during the semester as a performance test
3. submission of 2 out of 3 written homework assignments (texts) during the semester

**Recommendation**

Strong motivation for self-study
3.17 Course: German at ID A2.1 [T-IDSCHOOLS-112581]

**Responsible:** Katrina Pangritz

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** M-IDSCHOOLS-102357 - German at ID A2.1

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**Events**

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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

**Competence Certificate**

The results of the module will be assessed in the form of a 90-minute written examination and a presentation (examination of another type) pursuant to § 4 Para. 2 No. 1 and No. 3, SPO Master “Optics & Photonics”.

**Prerequisites**

Successful completion of German level A1.2 or German A1

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester
2. passing 2 out of 3 tests written during the semester as a performance test
3. submission of 2 out of 3 written homework assignments (texts) during the semester
4. presentation

**Recommendation**

Strong motivation for self-study
3.18 Course: German at ID A2.2 [T-IDSCHOOLS-112587]

**Responsible:** Katrina Pangritz  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-IDSCHOOLS-104605 - German at ID A2.2

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**Competence Certificate**
The results of the module will be assessed in the form of a 90-minute written examination and a presentation (examination of another type) pursuant to § 4 Para. 2 No. 1 and No. 3, SPO Master "Optics & Photonics".

**Prerequisites**
Successful completion of German level A2.1

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester
2. passing 2 out of 3 tests written during the semester as a performance test
3. submission of 2 out of 3 written homework assignments (texts) during the semester
4. presentation
### 3.19 Course: German at ID B1.1 - written examination [T-IDSCHOOLS-110691]

**Responsible:** Katrina Pangritz  
**Organisation:** Part of: M-IDSCHOOLS-102359 - German at ID B1.1

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#### Events

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#### Exams

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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

#### Competence Certificate

The results of the module will be assessed in the form of a 120-minute written examination and a presentation (examination of another type) pursuant to § 4 Para. 2 No. 1 and No. 3, SPO Master “Optics & Photonics”.

#### Prerequisites

Successful completion of German level A2.2 or German A2

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester
2. passing 2 out of 3 tests written during the semester as a performance test
3. submission of 2 out of 3 written homework assignments (texts) during the semester
4. presentation

#### Recommendation

Strong motivation for self-study.
### Course: German at ID B1.2 - written examination [T-IDSCHOOLS-110699]

**Responsible:** Katrina Pangritz  
**Organisation:**  
**Part of:** M-IDSCHOOLS-103230 - German at ID B1.2

#### Type
- **Written examination**

#### Credits
- **4**

#### Grading scale
- Grade to a third

#### Recurrence
- Each summer term

#### Expansion
- 1 terms

#### Version
- 3

#### Events

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#### Exams

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#### Competence Certificate

The results of the module will be assessed in the form of a 120-minute written examination and a presentation (examination of another type) pursuant to § 4 Para. 2 No. 1 and No. 3, SPO Master "Optics & Photonics".

#### Prerequisites

Successful completion of German level B1.1

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester
2. passing 2 out of 3 tests written during the semester as a performance test
3. submission of 2 out of 3 written homework assignments (texts) during the semester
4. presentation

#### Recommendation

Strong motivation for self-study
3.21 Course: German at ID B2.1 - Written Examination [T-IDSCHOOLS-110703]

**Responsible:** Katrina Pangritz

**Organisation:**
- **Part of:** M-IDSCHOOLS-104606 - German at ID B2.1

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**Events**

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**Exams**

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<td>Grade to a third</td>
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**Legend:** 🖥 Online, 🎨 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**
The results of the module will be assessed in the form of a 120-minute written examination and a presentation (examination of another type) pursuant to § 4 Para. 2 No. 1 and No. 3, SPO Master "Optics & Photonics".

**Prerequisites**
Successful completion of German level B1.2 or German B1

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester
2. passing 2 out of 3 tests written during the semester as a performance test
3. submission of 2 out of 3 written homework assignments (texts) during the semester
4. presentation

**Recommendation**
Strong motivation for self-study
3.22 Course: German at ID B2.2 - Written Examination [T-IDSCHOOLS-110647]

Responsible: Katrina Pangritz
Organisation: Part of: M-IDSCHOOLS-104607 - German at ID B2.2

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**Events**

| ST 2022 | 1400008 | German at ID B2.2 | Lecture / Practice ( / ) | Pangritz |

**Exams**

| ST 2022 | 34000014 | German at ID B2.2 - Exam | Pangritz |

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

**Competence Certificate**

The results of the module will be assessed in the form of a 120-minute written examination and a presentation (examination of another type) pursuant to § 4 Para. 2 No. 1 and No. 3, SPO Master "Optics & Photonics".

**Prerequisites**

Successful completion of German level B2.1

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester
2. passing 2 out of 3 tests written during the semester as a performance test
3. submission of 2 out of 3 written homework assignments (texts) during the semester
4. presentation

**Recommendation**

Strong motivation for self-study
### Course: German at ID C1.1 - written examination [T-IDSCHOOLS-111198]

**Responsible:** Katrina Pangritz  
**Organisation:**  
**Part of:** M-IDSCHOOLS-105583 - German at ID C1.1

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### Competence Certificate
The results of the module will be assessed in the form of a 120-minute written examination and a presentation (examination of another type) pursuant to § 4 Para. 2 No. 1 and No. 3, SPO Master "Optics & Photonics".

### Prerequisites
Successful completion of German level B2.2 or B2

In order to participate in the final exam at the end of the semester, participants must meet the following criteria:

1. at least 80% attendance in the course during the semester  
2. passing 2 out of 3 tests written during the semester as a performance test  
3. submission of 2 out of 3 written homework assignments (texts) during the semester  
4. presentation

### Recommendation
Strong motivation for self-study
3.24 Course: Imaging Techniques in Light Microscopy [T-CHEMBIO-105197]

**Responsible:** Prof. Dr. Martin Bastmeyer
**Organisation:** KIT Department of Chemistry and Biosciences
**Part of:** M-CHEMBIO-101905 - Imaging Techniques in Light Microscopy

<table>
<thead>
<tr>
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<td>3</td>
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**Exams**

| ST 2022 | 71105197 | Imaging Techniques in Light Microscopy | Bastmeyer |

**Competence Certificate**
Written exam over 120 minutes (depending on the number of participants oral exam over approx. 45 min).

Depending on the number of participants, a written exam (120 min) or an oral exam (approx. 45 min) is accomplished. The exact modality of the exam will be announced at the beginning of the semester. The written exam is scheduled for the beginning of the break after the WS. A resit exam is offered at the end of the break.

**Prerequisites**
none

**Recommendation**
Attendance to the lecture. Basic knowledge in physics and biology.
3.25 Course: Internship Presentation [T-ETIT-105127]

**Responsible:** Prof. Dr. Ulrich Lemmer
Prof. Dr.-Ing. Christoph Stiller

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** M-ETIT-102360 - Internship

<table>
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</table>

**Competence Certificate**

The internship is a study achievement (study and examinations Regulation, § 4 (3)). A minimum of working hours equivalent to 8 weeks of full-time work (excluding holidays and public holidays) must be completed.

Furthermore the following three parts must be provided:

1. A company confirmation about the completion of the internship

**Internship confirmation/certificate from industry or research institute.**

The internship confirmation is issued directly by the company or institute, respectively, after the internship is completed. The confirmation should be signed by the local supervisor and contain the following information: (1) the student's name, birthday and matriculation number, (2) start and end date of the internship (minimum eight weeks without vacations), (3) the title of the project, and (4) Company Name (institute, sector and supervisor). Please note that the internship contract is not valid as a certificate.

2. Delivery of a written report on methodology and results (approx. 10 pages).

The internship report comprises a written report in the form of a seminar paper and an evaluation to be handed in to the KSOP student office.

-> Both documents (company confirmation and internship report) have to be send to the KSOP Office latest 2 weeks before the presentation date.

3. Presentation

In the internship presentation the students have to present the project work of their internships to a KSOP professor and their peers (who make the presentation on the same day; usually up to 15 students) followed by a discussion of the results.

For the presentation several dates (usually one every three month) are available per year. The dates are announced twice a year to the current students and students need to register online for the desired presentation date latest 15 days before the desired presentation date. After that the registration will be closed.

The 12 credit points are awarded after passing the company confirmation, internship report and presentation. The decision is made by a KSOP professor.

**Prerequisites**

Scientific background in Optics and Photonics

**Recommendation**

Scientific background in Optics and Photonics.
3.26 Course: Introduction to Automotive and Industrial Lidar Technology [T-ETIT-111011]

Responsible: Prof. Dr. Wilhelm Stork
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105461 - Introduction to Automotive and Industrial Lidar Technology

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Exams

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<td>Introduction to automotive and industrial Lidar technology</td>
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3.27 Course: Introduction to the Scientific Method (Seminar, Englisch) [T-ETIT-111317]

**Responsible:** Prof. Dr. Werner Nahm

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** M-ETIT-105665 - Introduction to the Scientific Method (Seminar, English)

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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**

The success control takes place in the form of a study achievement. The exam consists of the preparation and the presentation of a seminar paper.

**Prerequisites**

none

**Annotation**

Detailed information on contents, competence goals, and work load at:

M-ETIT-105665 – Introduction to the Scientific Method (Seminar)
3 Course: Laser Metrology [T-ETIT-100643]

Responsible: Prof. Dr. Marc Eichhorn
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100434 - Laser Metrology

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<td>Eichhorn</td>
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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ⌚ Cancelled

Prerequisites
none

Below you will find excerpts from events related to this course:

Current time schedule can be found in ILIAS

Organizational issues
Beginn am Do. 21. April, 10:00 - 13:15
Seminarraum IRS, Raum 312 Geb. 30.33 (ggf. online per MS-Teams).
Weitere Details werden in ILIAS bekannt gegeben. Prüfungen werden ebenfalls über ILIAS organisiert
Starting on Thursday, 21.April, 10:00 - 13:15
Room 312, Building 30.33 (possibly online via MS Teams)
Further details are announced in ILIAS. Exam registration will also be organised via ILIAS.
Course: Laser Physics [T-ETIT-100741]

**3.29 Course: Laser Physics [T-ETIT-100741]**

- **Responsible:** Prof. Dr. Marc Eichhorn
- **Organisation:** KIT Department of Electrical Engineering and Information Technology
- **Part of:** M-ETIT-100435 - Laser Physics

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Legend: 🖥 Online, ⬅ Blended (On-Site/Online), ⬆ On-Site, ✗ Cancelled

**Prerequisites**
none
# 3.30 Course: Light and Display Engineering [T-ETIT-100644]

**Responsible:** Dr.-Ing. Rainer Kling  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-100512 - Light and Display Engineering  
**Type:** Oral examination  
**Credits:** 4  
**Grading scale:** Grade to a third  
**Recurrence:** Each winter term  
**Version:** 1

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**Prerequisites**

none

**Legend:** 🖥 Online, ⏳ Blended (On-Site/Online), 🗣️ On-Site, ✗ Cancelled
3.31 Course: Lighting Design - Theory and Applications [T-ETIT-100997]

**Responsible:** Dr.-Ing. Rainer Kling

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** M-ETIT-100577 - Lighting Design - Theory and Applications

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**Exams**

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**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🔗 On-Site, ✗ Cancelled

**Prerequisites**

none
### Course: Machine Vision [T-MACH-105223]

**Responsible:** Dr. Martin Lauer  
Prof. Dr.-Ing. Christoph Stiller

**Organisation:** KIT Department of Mechanical Engineering

**Part of:** M-MACH-101923 - Machine Vision

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<td>Machine Vision</td>
<td>English</td>
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</table>

**Competence Certificate**

- **Type of Examination:** written exam  
- **Duration of Examination:** 60 minutes  
- **Prerequisites:** None

Below you will find excerpts from events related to this course:

---

**Machine Vision**

- **Foliensatz zur Veranstaltung:** wird als kostenlose pdf-Datei bereitgestellt. Weitere Empfehlungen werden in der Vorlesung bekannt gegeben.
3.33 Course: Master's Thesis [T-ETIT-112630]

**Responsible:** Prof. Dr. Cornelius Neumann  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-106212 - Module Master's Thesis

**Competence Certificate**  
The master's thesis module consists of the master's thesis and a presentation. The presentation shall be made within six months upon registration for the master's thesis.

**Prerequisites**  
Prerequisites according to:  
*Study and Examination Regulations of Karlsruhe Institute of Technology (KIT) Relating to the Master’s Program “Optics & Photonics” (dated August 04, 2015)*  
Article 14 - Master’s Thesis Module  
(1) Students who have successfully passed all module examinations and internships required except for two module examinations at the maximum shall be accepted for the master’s thesis module. Prior to the registration of the master’s thesis module, the optics and photonics labs, the seminar course, and the internship have to be passed. The application for admission to the master’s thesis shall be submitted three months after the last module examination at the latest. At request of the student, the examination board shall decide on exceptions.

**Modeled Conditions**  
The following conditions have to be fulfilled:  
1. The course **T-ETIT-112631 - Precondition Master's Thesis** must have been passed.

**Final Thesis**  
This course represents a final thesis. The following periods have been supplied:  
- **Submission deadline** 6 months  
- **Maximum extension period** 3 months  
- **Correction period** 8 weeks  
This thesis requires confirmation by the examination office.
### Course: Measurement and Control Systems [T-MACH-103622]

**Responsible:** Prof. Dr.-Ing. Christoph Stiller  
**Organisation:** KIT Department of Mechanical Engineering

**Part of:** M-MACH-101921 - Measurement and Control Systems

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**Exams**

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**Prerequisites**

none

Below you will find excerpts from events related to this course:

#### Measurement and Control Systems

**3137020, WS 22/23, 3 SWS, Language: English, Open in study portal**

**Lecture (V) On-Site**

**Content**

**Lehrinhalt (EN):**

1. Dynamic systems  
2. Properties of important systems and modeling  
3. Transfer characteristics and stability  
4. Controller design  
5. Fundamentals of measurement  
6. Estimation  
7. Sensors  
8. Introduction to digital measurement

**Lernziele (EN):**

Measurement and control of physical entities is a vital requirement in most technical applications. Such entities may comprise e.g. pressure, temperature, flow, rotational speed, power, voltage and electrical current, etc. From a general perspective, the objective of measurement is to obtain information about the state of a system while control aims to influence the state of a system in a desired manner. This lecture provides an introduction to this field and general systems theory. The control part of the lecture presents classical linear control theory. The measurement part discusses electrical measurement of non-electrical entities.

Nachweis (EN): written exam; duration 2,5 h; paper reference materials only (no calculator)

Arbeitsaufwand (EN): 180 hours
Literature

- Measurement and Control Systems:
  
  
  
  R. Dorf and R. Bishop: Modern Control Systems, Addison-Wesley
  
  
- Regelungstechnische Bücher:
  
  J. Lunze: Regelungstechnik 1 & 2, Springer-Verlag
  
  R. Unbehauen: Regelungstechnik 1 & 2, Vieweg-Verlag
  
  O. Föllinger: Regelungstechnik, Hüthig-Verlag
  
  W. Leonhard: Einführung in die Regelungstechnik, Teubner-Verlag
  
  
- Messtechnische Bücher:
  
  E. Schrüfer: Elektrische Meßtechnik, Hanser-Verlag, München, 5. Aufl., 1992
  
  
  
  W. Pfeiffer: Elektrische Messtechnik, VDE Verlag Berlin 1999
  
  Kronmüller, H.: Prinzipien der Prozeßmeßtechnik 2, Schnäcker-Verlag, Karlsruhe, 1. Aufl., 1980

Measurement and Control Systems (Tutorial)
3137021, WS 22/23, 1 SWS, Language: English, Open in study portal

Content
Tutorial for Measurement and Control Systems
### T 3.35 Course: Modern Physics [T-PHYS-103629]

**Responsible:** apl. Prof. Dr. Bernd Pilawa  
**Organisation:** KIT Department of Physics  
**Part of:** M-PHYS-101931 - Modern Physics

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**Legend:** 🖥 Online, 📦 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**  
Written exam (usually about 180 min)

**Prerequisites**  
none
3.36 Course: Molecular Spectroscopy [T-CHEMBIO-101864]

 Organisation: KIT Department of Chemistry and Biosciences
 Part of: M-CHEMBIO-101902 - Molecular Spectroscopy

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Prerequisites
acc. to module catalogue
### 3.37 Course: Nano-Optics [T-PHYS-102282]

**Responsible:** Dr. Andreas Naber  
**Organisation:** KIT Department of Physics  
**Part of:** M-PHYS-102146 - Nano-Optics

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**Legend:** 🖥 Online, 🏗 Blended (On-Site/Online), ⏯ On-Site, ✗ Cancelled

**Prerequisites**

none
### 3.38 Course: Nonlinear Optics [T-ETIT-101906]

**Responsible:** Prof. Dr.-Ing. Christian Koos  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-100430 - Nonlinear Optics

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Legend: 💻 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Prerequisites**

*none*
# 3.39 Course: Optical Engineering [T-ETIT-100676]

**Responsible:** Prof. Dr. Wilhelm Stork  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-100456 - Optical Engineering

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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

### Competence Certificate

Achievement will be examined in an oral examination (approx. 20 minutes)

### Prerequisites

none
### 3.40 Course: Optical Networks and Systems [T-ETIT-106506]

**Responsible:** Prof. Dr.-Ing. Sebastian Randel  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-103270 - Optical Networks and Systems

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#### Exams

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**Prerequisites**

none
**Course: Optical Systems in Medicine and Life Science [T-ETIT-106462]**

**Responsible:** Prof. Dr. Werner Nahm

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** M-ETIT-103252 - Optical Systems in Medicine and Life Science

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Legend: 🛥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Competence Certificate**

Written exam (60 minutes)

**Prerequisites**

Only one out of the two modules "M-ETIT-100552 - Optische Systeme für Medizintechnik und Life Sciences" and "M-ETIT-103252 - Optical Systems in Medicine and Life Science" is allowed.

**Recommendation**

Good understanding of optics and optoelectronics.

**Annotation**

Language English
### 3.42 Course: Optical Transmitters and Receivers [T-ETIT-100639]

**Responsible:** Prof. Dr. Wolfgang Freude  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-100436 - Optical Transmitters and Receivers

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**Prerequisites**

none
3.43 Course: Optical Waveguides and Fibers [T-ETIT-101945]

**Responsible:** Prof. Dr.-Ing. Christian Koos

**Organisation:** KIT Department of Electrical Engineering and Information Technology

**Part of:** M-ETIT-100506 - Optical Waveguides and Fibers

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**Prerequisites**

none
### Course: Optics and Photonics Lab [T-PHYS-104511]

<table>
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<th>Responsible</th>
<th>PD Dr. Michael Hetterich</th>
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<td>Part of</td>
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**Type** | **Completed coursework** | **Credits** | **Grading scale** | **Version** |
---|---|---|---|---|
| **Completed coursework** | | **5** | **pass/fail** | **1** |

**Events**

| ST 2022 | 2309491 | Optics and Photonics Lab (KSOP) | 4 SWS | Practical course / | Koos, Freude, Randel |
| ST 2022 | 4044123 | KSOP Optics & Photonics Lab II | 4 SWS | Practical course / | Hetterich |
| ST 2022 | 5254 | Praktikum Optics and Photonics Lab II (KSOP) | 4 SWS | Practical course / | Kappes, Unterreiner, Lebedkin |
| ST 2022 | 7146 | KSOP Optics and Photonics Lab II | 4 SWS | Practical course / | Bastmeyer, Weth |
| WT 22/23 | 2309491 | Optics & Photonics Lab KSOP | 4 SWS | Practical course / | Freude, Koos, Randel, N.N., Eschenbaum, Peng, Zhdanov, Foroutan Barenji |
| WT 22/23 | 4044113 | KSOP - Optics & Photonics Lab I | 4 SWS | Practical course / | Hetterich |
| WT 22/23 | 7287 | KSOP Optics and Photonics Lab I | Practical course / | Bastmeyer, Weth |

**Exams**

| ST 2022 | 7800071 | Optics and Photonics Lab | Hetterich |

**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Prerequisites**

none
3.45 Course: Optics and Vision in Biology [T-CHEMBIO-105198]

**Responsible:** Prof. Dr. Martin Bastmeyer

**Organisation:** KIT Department of Chemistry and Biosciences

**Part of:** M-CHEMBIO-101906 - Optics and Vision in Biology

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**Exams**

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**Competence Certificate**

Type of Examination: Written exam

Duration of Examination: 120 Minutes

Modality of Exam: The written exam is scheduled for the break after the WS. A resit exam will be offered, when needed.

**Prerequisites**

none

**Recommendation**

Passed exam of the Adjustment Course in "Basic Molecular Cell Biology" AdjC-BMCB.

Attendance to the lecture.

**Annotation**

Prerequisite for exam participation: Passed exam of the Adjustment Course in “Basic Molecular Cell Biology”.

Anmerkungen engl.
3.46 Course: Optoelectronic Components [T-ETIT-101907]

**Responsible:** Prof. Dr. Wolfgang Freude  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-100509 - Optoelectronic Components

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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ❌ Cancelled

**Prerequisites**

none
3.47 Course: Organic Photochemistry [T-CHEMBIO-105195]

**Organisation:** KIT Department of Chemistry and Biosciences
**Part of:** M-CHEMBIO-101907 - Organic Photochemistry

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**Prerequisites**

acc. to module catalogue
Course: Photonic Integrated Circuit Design and Applications [T-ETIT-111896]

Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-105914 - Photonic Integrated Circuit Design and Applications

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Exams

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Competence Certificate

- Part 1 – Solutions of problem sets: We will grade your solutions of the various problem sets and design projects. To this end, please upload your solution via the online teaching platform of your respective institution (see above) before the respective deadline. Please merge all pages into a single pdf file, and please use a scanner. Smartphone made snapshots are often illegible, and in this case your solutions cannot be evaluated. In case there are any technical difficulties with the platforms, you may also submit your solutions by e-mail to picda@ipq.kit.edu before the respective deadline.
- Part 2 - Presentation of one pre-assigned problem set: At the beginning of the term, design projects will be pre-assigned to groups of participants. Each of these groups will explain their approach and results to lecturers and peer students in a short presentation (approx. 15 min), followed by approx. 10 min of public discussion with peer students and professors, and an individual private interview of each group member (approx. 10 min per person).

The overall impression is rated.

Prerequisites
none
### Course: Plastic Electronics / Polymerelectronics [T-ETIT-100763]

**Responsible:** Prof. Dr. Ulrich Lemmer  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-100475 - Plastic Electronics / Polymerelectronics

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**Exams**

| ST 2022   | 7313709  | Plastic Electronics / Polymerelectronics | Lemmer |
| WT 22/23  | 7313709  | Plastic Electronics / Polymerelectronics | Lemmer |

**Legend:** 🖥 Online, 🧩 Blended (On-Site/Online), 🔴 On-Site, ✗ Cancelled

**Competence Certificate**

oral exam (approx. 20 minutes)

**Prerequisites**

none
3.50 Course: Quantum Optics [T-PHYS-106135]

**Responsible:** Prof. Dr. Carsten Rockstuhl  
**Organisation:** KIT Department of Physics  
**Part of:** M-PHYS-103093 - Quantum Optics

<table>
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**Exams**

| Exams | ST 2022 | 7800128 | Quantum Optics | Rockstuhl |

Optics and Photonics Master 20151 (Master of Science (M.Sc.))  
Module Handbook as of 24/10/2022
3.51 Course: Quantum Optics at the Nano Scale: Basics and Applications, without Exercises [T-PHYS-108480]

Responsible: Prof. Dr. David Hunger
Organisation: KIT Department of Physics
Part of: M-PHYS-104094 - Quantum Optics at the Nano Scale: Basics and Applications, without Exercises

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Type: Oral examination
Credits: 6
Grading scale: Grade to a third
Recurrence: Irregular
Version: 1

Prerequisites: none
3.52 Course: Quantum Optics at the Nano Scale: Basics and Applications, with Exercises [T-PHYS-108478]

**Responsible:** Prof. Dr. David Hunger

**Organisation:** KIT Department of Physics

**Part of:** M-PHYS-104092 - Quantum Optics at the Nano Scale: Basics and Applications, with Exercises

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**Events**

| ST 2022 | 4021161 | Quantum Optics at the Nano Scale: Fundamentals and Applications | 3 SWS | Lecture / 🗣 | Hunger |
| ST 2022 | 4021162 | Übungen zu Quantum Optics at the Nano Scale: Fundamentals and Applications | 1 SWS | Practice / 🗣 | Hunger, Hessenauer |

**Exams**

| ST 2022 | 7800120 | Quantum Optics at the Nano Scale: Basics and Applications, with Exercises | Hunger |

Legend: 🖥 Online, 🌐 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

**Prerequisites**

none
3.53 Course: Research Project [T-PHYS-103632]

**Responsible:** Prof. Dr. Heinz Kalt

**Organisation:** KIT Department of Physics

**Part of:** M-PHYS-102194 - Research Project

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**Prerequisites**

none
### 3.54 Course: Seminar Course [T-PHYS-104516]

**Responsible:** Prof. Dr. David Hunger  
**Organisation:** KIT Department of Physics  
**Part of:** M-PHYS-102195 - Seminar Course

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**Prerequisites**  
none

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Optics and Photonics Master 20151 (Master of Science (M.Sc.))  
Module Handbook as of 24/10/2022
3.55 Course: Solar Energy [T-ETIT-100774]

**Responsible:** Prof. Dr. Bryce Sydney Richards  
**Organisation:** KIT Department of Electrical Engineering and Information Technology  
**Part of:** M-ETIT-100524 - Solar Energy

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Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

**Prerequisites**  
Students not allowed to take either of the following modules in addition to this one: „Solarenergie“ (M-ETIT-100476) and „Photovoltaik“ (M-ETIT-100513).
Course: Solar Thermal Energy Systems [T-MACH-106493]

**Responsible:** apl. Prof. Dr. Ron Dagan  
**Organisation:** KIT Department of Mechanical Engineering

**Part of:** M-MACH-101924 - Solar Thermal Energy Systems

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**Events**

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Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗤 On-Site, ✗ Cancelled

**Competence Certificate**  
oral exam of about 30 minutes

**Prerequisites**  
none

**Recommendation**

**Literature**


Below you will find excerpts from events related to this course:

**V Solar Thermal Energy Systems**  
2189400, WS 22/23, 2 SWS, Language: English, Open in study portal
Content
The course deals with fundamental aspects of solar energy
1. Introduction to solar energy – global energy panorama
2. Solar energy resource-
   Structure of the sun, Black body radiation, solar constant, solar spectral distribution
   Sun-Earth geometrical relationship
3. Passive and active solar thermal applications.
4. Solar thermal systems- solar collector-types, concentrating collectors, solar towers,
   Heat losses, efficiency
5. Selected topics on thermodynamics and heat transfer which are relevant for solar systems.
6. Introduction to Solar induced systems: Wind , Heat pumps, Biomass , Photovoltaic
7. Energy storage

The course deals with fundamental aspects of solar energy. Starting from a global energy panorama the course deals with the sun as a thermal energy source. In this context, basic issues such as the sun's structure, blackbody radiation and solar–earth geometrical relationship are discussed. In the next part, the lectures cover passive and active thermal applications and review various solar collector types including concentrating collectors and solar towers and the concept of solar tracking. Further, the collector design parameters determination is elaborated, leading to improved efficiency. This topic is augmented by a review of the main laws of thermodynamics and relevant heat transfer mechanisms.

The course ends with an overview on energy storage concepts which enhance practically the benefits of solar thermal energy systems.

The students get familiar with the global energy demand and the role of renewable energies learn about improved designs for using efficiently the potential of solar energy gain basic understanding of the main thermal hydraulic phenomena which support the work on future innovative applications will be able to evaluate quantitatively various aspects of the thermal solar systems.

Total 120 h, hereof 30 h contact hours and 90 h homework and self-studies
oral exam about 30 min.

Organizational issues
Die Veranstaltung wird nur online gehalten, falls durch Corona Einschränkungen vorgegeben werden.

Literature
- "Fundamentals of classical Thermodynamics", G. Van Wylen & R. E. Sonntag. Published by Wiley & Sons
### 3.57 Course: Solid-State Optics, without Exercises [T-PHYS-104773]

- **Responsible:** PD Dr. Michael Hetterich  
  Prof. Dr. Heinz Kalt  
- **Organisation:** KIT Department of Physics  
- **Part of:** M-PHYS-102408 - Solid-State Optics

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**Legend:** 🖥 Online, 🗦 Blended (On-Site/Online), 🗣️ On-Site, ✗ Cancelled

**Prerequisites**

none
### 3.58 Course: Spectroscopic Methods [T-CHEMBIO-103590]

**Organisation:** KIT Department of Chemistry and Biosciences  
**Part of:** M-CHEMBIO-101900 - Spectroscopic Methods

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**Prerequisites**  
acc. to module catalogue
### Course: Systems and Software Engineering [T-ETIT-100675]

- **Responsible:** Prof. Dr.-Ing. Eric Sax
- **Organisation:** KIT Department of Electrical Engineering and Information Technology
- **Part of:** M-ETIT-100537 - Systems and Software Engineering

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**Legend:** 📝 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✗ Cancelled

### Competence Certificate

Written exam, approx. 120 minutes, (§4 (2), 1 SPO).

### Prerequisites

none

### Recommendation

Participation in the lectures Digital System Design and Information Technology is advised.
### 3.60 Course: Theoretical Nanooptics [T-PHYS-104587]

**Responsible:** Prof. Dr. Carsten Rockstuhl  
**Organisation:** KIT Department of Physics  
**Part of:** M-PHYS-102295 - Theoretical Nanooptics

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Legend: 🖥 Online, 🌐 Blended (On-Site/Online), 🗺 On-Site, ✗ Cancelled
3.61 Course: Theoretical Optics [T-PHYS-102278]

**Responsible:** Prof. Dr. Carsten Rockstuhl

**Organisation:** KIT Department of Physics

**Part of:** M-PHYS-102280 - Theoretical Optics

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**Exams**

| ST 2022 | 7800087 | Theoretical Optics - Exam 1 | Rockstuhl |
| ST 2022 | 7800088 | Theoretical Optics - Exam 2 | Rockstuhl |

**Prerequisites**

Successful participation in the exercises

**Modeled Conditions**
The following conditions have to be fulfilled:

1. The course T-PHYS-102305 - Theoretical Optics - Unit must have been passed.
3.62 Course: Theoretical Optics - Unit [T-PHYS-102305]

**Responsible:** Prof. Dr. Carsten Rockstuhl  
**Organisation:** KIT Department of Physics  
**Part of:** M-PHYS-102280 - Theoretical Optics

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**Prerequisites**
none
3.63 Course: X-Ray Optics [T-MACH-103624]

**Responsible:** Dr. Arndt Last

**Organisation:** KIT Department of Mechanical Engineering

**Part of:** M-MACH-101920 - X-Ray Optics

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**Competence Certificate**

oral exam

**Prerequisites**

none