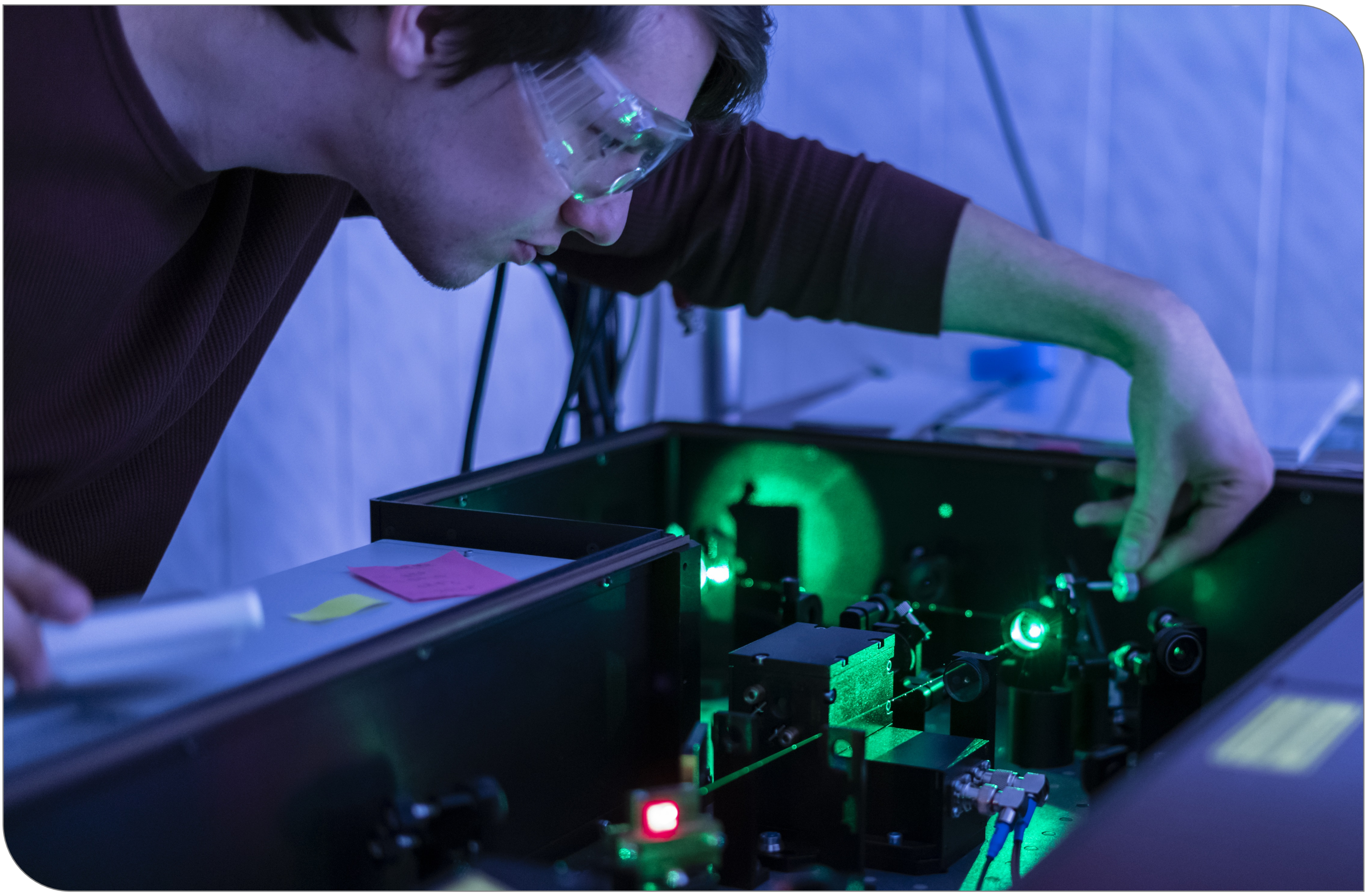
Module Handbook
Optics and Photonics Master 20151 (Master of Science (M.Sc.))

SPO 20151

Winter term 2022/23

Date: 24/10/2022

KIT DEPARTMENT OF ELECTRICAL ENGINEERING AND INFORMATION TECHNOLOGY



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1 Field of study structure

Mandatory	
Master's Thesis	30 CR
Internship	12 CR
Engineering Optics & Photonics	8 CR
Physical Optics & Photonics	8 CR
Advanced Optics & Photonics – Theory and Materials	8 CR
Advanced Optics & Photonics – Methods and Components	10 CR
Adjustment Courses *This field will not influence the calculated grade of its parent.*	8 CR
Optics & Photonics Lab *This field will not influence the calculated grade of its parent.*	10 CR
Seminar Course (Research Topics in Optics & Photonics) *This field will not influence the calculated grade of its parent.*	4 CR
Interdisciplinary Qualification *This field will not influence the calculated grade of its parent.*	6 CR
Specialization (Election: 1 item)	
Specialization - Photonic Materials and Devices	16 CR
Specialization - Biomedical Photonics	16 CR
Specialization - Optical Systems	16 CR
Specialization - Solar Energy	16 CR
Specialization - Quantum Optics & Spectroscopy	16 CR
Voluntary	
Additional Examinations *This field will not influence the calculated grade of its parent.*	

1.1 Master's Thesis

Credits
30

Mandatory		
M-ETIT-106212	Module Master's Thesis neu	30 CR

1.2 Internship

Credits
12

Mandatory		
M-ETIT-102360	Internship neu	12 CR

1.3 Engineering Optics & Photonics

Credits
8

Engineering Optics & Photonics (Election: 8 credits)		
M-ETIT-100386	Electromagnetics and Numerical Calculation of Fields neu	4 CR
M-ETIT-100456	Optical Engineering neu	4 CR

1.4 Physical Optics & Photonics

Credits
8

Physical Optics & Photonics (Election: 8 credits)		
M-PHYS-101927	Fundamentals of Optics and Photonics neu	8 CR

1.5 Advanced Optics & Photonics – Theory and Materials

Credits
8

Mandatory		
M-PHYS-102280	Theoretical Optics neu	4 CR
M-ETIT-100430	Nonlinear Optics neu	4 CR

1.6 Advanced Optics & Photonics – Methods and Components

Credits
10

Mandatory		
M-ETIT-100509	Optoelectronic Components neu	4 CR
M-ETIT-101919	Fabrication and Characterisation of Optoelectronic Devices neu	3 CR
M-CHEMBIO-101900	Spectroscopic Methods neu	3 CR

1.7 Adjustment Courses

Credits
8

Mandatory		
M-CHEMBIO-101903	Basic Molecular Cell Biology neu	2 CR
Modern Physics / Measurement and Control Systems (Election: 1 item)		
M-PHYS-101931	Modern Physics neu	6 CR
M-MACH-101921	Measurement and Control Systems neu	6 CR

1.8 Optics & Photonics Lab

Credits
10

Mandatory		
M-PHYS-102189	Optics and Photonics Lab neu	10 CR

1.9 Seminar Course (Research Topics in Optics & Photonics)

Credits
4

Mandatory		
M-PHYS-102195	Seminar Course neu	4 CR

1.10 Interdisciplinary Qualification

Credits
6

Interdisciplinary Qualification (Election: at least 6 credits)		
M-IDSCHOOLS-102357	German at ID A2.1 neu	4 CR
M-IDSCHOOLS-102359	German at ID B1.1 neu	4 CR
M-ETIT-101834	Business Innovation in Optics and Photonics neu	4 CR
M-ETIT-105665	Introduction to the Scientific Method (Seminar, English) neu	1 CR
M-IDSCHOOLS-103230	German at ID B1.2 neu	4 CR
M-IDSCHOOLS-104603	German at ID A1.1 neu	4 CR
M-IDSCHOOLS-104606	German at ID B2.1 neu	4 CR
M-IDSCHOOLS-104604	German at ID A1.2 neu	4 CR
M-IDSCHOOLS-104605	German at ID A2.2 neu	4 CR
M-IDSCHOOLS-104607	German at ID B2.2 neu	4 CR
M-IDSCHOOLS-105583	German at ID C1.1 neu	4 CR

1.11 Specialization - Photonic Materials and Devices

Credits
16

Specialization - Photonic Materials and Devices (Election: at least 16 credits)		
M-ETIT-100435	Laser Physics neu	4 CR
M-ETIT-100436	Optical Transmitters and Receivers neu	6 CR
M-ETIT-100506	Optical Waveguides and Fibers neu	4 CR
M-ETIT-100524	Solar Energy neu	6 CR
M-ETIT-100566	Field Propagation and Coherence neu	4 CR
M-PHYS-102194	Research Project neu	4 CR
M-PHYS-102408	Solid-State Optics neu	8 CR
M-MACH-101920	X-Ray Optics neu	3 CR
M-ETIT-100475	Plastic Electronics / Polymerelectronics neu	3 CR
M-CHEMBIO-101901	Advanced Inorganic Materials neu	3 CR
M-PHYS-102146	Nano-Optics neu	8 CR
M-PHYS-103093	Quantum Optics neu	6 CR
M-PHYS-103089	Computational Photonics, without ext. Exercises neu	6 CR
M-ETIT-103270	Optical Networks and Systems neu	4 CR
M-ETIT-103802	Adaptive Optics neu	3 CR
M-PHYS-102295	Theoretical Nanooptics neu	6 CR
M-ETIT-105914	Photonic Integrated Circuit Design and Applications neu	6 CR

1.12 Specialization - Biomedical Photonics

Credits 16

Compulsory Modules (Election: at least 5 credits)		
M-CHEMBIO-101904	Advanced Molecular Cell Biology neu	5 CR
Compulsory Elective Modules (Election: at least 11 credits)		
M-ETIT-100435	Laser Physics neu	4 CR
M-PHYS-102146	Nano-Optics neu	8 CR
M-PHYS-102194	Research Project neu	4 CR
M-CHEMBIO-101907	Organic Photochemistry neu	3 CR
M-CHEMBIO-101905	Imaging Techniques in Light Microscopy neu	3 CR
M-CHEMBIO-101906	Optics and Vision in Biology neu	4 CR
M-ETIT-103252	Optical Systems in Medicine and Life Science neu	3 CR
M-ETIT-103802	Adaptive Optics neu	3 CR

1.13 Specialization - Optical Systems

Credits 16

Specialization - Optical Systems (Election: at least 16 credits)		
M-ETIT-100434	Laser Metrology neu	3 CR
M-ETIT-100435	Laser Physics neu	4 CR
M-ETIT-100436	Optical Transmitters and Receivers neu	6 CR
M-ETIT-100506	Optical Waveguides and Fibers neu	4 CR
M-ETIT-100512	Light and Display Engineering neu	4 CR
M-ETIT-100537	Systems and Software Engineering neu	5 CR
M-ETIT-100566	Field Propagation and Coherence neu	4 CR
M-ETIT-100577	Lighting Design - Theory and Applications neu	3 CR
M-PHYS-102194	Research Project neu	4 CR
M-MACH-101923	Machine Vision neu	8 CR
M-ETIT-100475	Plastic Electronics / Polymerelectronics neu	3 CR
M-PHYS-103093	Quantum Optics neu	6 CR
M-PHYS-103089	Computational Photonics, without ext. Exercises neu	6 CR
M-ETIT-103252	Optical Systems in Medicine and Life Science neu	3 CR
M-MACH-102693	Automotive Vision neu	6 CR
M-ETIT-103270	Optical Networks and Systems neu	4 CR
M-ETIT-103450	Digital Signal Processing in Optical Communications – with Practical Exercises neu	6 CR
M-MACH-101920	X-Ray Optics neu	3 CR
M-PHYS-102295	Theoretical Nanooptics neu	6 CR
M-ETIT-105461	Introduction to Automotive and Industrial Lidar Technology neu	3 CR
M-ETIT-105914	Photonic Integrated Circuit Design and Applications neu	6 CR
M-ETIT-103802	Adaptive Optics neu	3 CR

1.14 Specialization - Solar Energy

Credits
16

Compulsory Modules (Election: at least 6 credits)		
M-ETIT-100524	Solar Energy neu	6 CR
Compulsory Elective Modules (Election: at least 10 credits)		
M-ETIT-101917	Electric Power Generation and Power Grid neu	3 CR
M-PHYS-102194	Research Project neu	4 CR
M-PHYS-102408	Solid-State Optics neu	8 CR
M-ETIT-100475	Plastic Electronics / Polymerelectronics neu	3 CR
M-PHYS-102146	Nano-Optics neu	8 CR
M-PHYS-103089	Computational Photonics, without ext. Exercises neu	6 CR
M-MACH-101924	Solar Thermal Energy Systems neu	4 CR
M-PHYS-102295	Theoretical Nanooptics neu	6 CR

1.15 Specialization - Quantum Optics & Spectroscopy

Credits
16

Specialization - Quantum Optics & Spectroscopy (Election: at least 16 credits)		
M-ETIT-100435	Laser Physics neu	4 CR
M-ETIT-100434	Laser Metrology neu	3 CR
M-PHYS-102146	Nano-Optics neu	8 CR
M-PHYS-102194	Research Project neu	4 CR
M-PHYS-102408	Solid-State Optics neu	8 CR
M-CHEMBIO-101901	Advanced Inorganic Materials neu	3 CR
M-CHEMBIO-101902	Molecular Spectroscopy neu	4 CR
M-PHYS-103093	Quantum Optics neu	6 CR
M-ETIT-103802	Adaptive Optics neu	3 CR
M-PHYS-104092	Quantum Optics at the Nano Scale: Basics and Applications, with Exercises neu	8 CR
M-PHYS-104094	Quantum Optics at the Nano Scale: Basics and Applications, without Exercises neu	6 CR
M-ETIT-105914	Photonic Integrated Circuit Design and Applications neu	6 CR

1.16 Additional Examinations

Additional Examinations (Election: at most 30 credits)		
M-ETIT-102000	Further Examinations neu	30 CR
M-ETIT-100435	Laser Physics neu	4 CR
M-ETIT-100436	Optical Transmitters and Receivers neu	6 CR
M-ETIT-100506	Optical Waveguides and Fibers neu	4 CR
M-ETIT-100566	Field Propagation and Coherence neu	4 CR
M-PHYS-102194	Research Project neu	4 CR
M-PHYS-102408	Solid-State Optics neu	8 CR
M-MACH-101920	X-Ray Optics neu	3 CR
M-ETIT-100434	Laser Metrology neu	3 CR
M-PHYS-102146	Nano-Optics neu	8 CR
M-ETIT-100512	Light and Display Engineering neu	4 CR
M-ETIT-100537	Systems and Software Engineering neu	5 CR
M-ETIT-100577	Lighting Design - Theory and Applications neu	3 CR
M-MACH-101923	Machine Vision neu	8 CR
M-ETIT-100524	Solar Energy neu	6 CR
M-ETIT-101917	Electric Power Generation and Power Grid neu	3 CR
M-ETIT-100475	Plastic Electronics / Polymerelectronics neu	3 CR
M-CHEMBIO-101901	Advanced Inorganic Materials neu	3 CR
M-CHEMBIO-101902	Molecular Spectroscopy neu	4 CR
M-CHEMBIO-101904	Advanced Molecular Cell Biology neu	5 CR
M-CHEMBIO-101905	Imaging Techniques in Light Microscopy neu	3 CR
M-CHEMBIO-101906	Optics and Vision in Biology neu	4 CR
M-CHEMBIO-101907	Organic Photochemistry neu	3 CR
M-ETIT-103252	Optical Systems in Medicine and Life Science neu	3 CR
M-IDSCHOOLS-102357	German at ID A2.1 neu	4 CR
M-IDSCHOOLS-102359	German at ID B1.1 neu	4 CR
M-MACH-102693	Automotive Vision neu	6 CR
M-PHYS-103089	Computational Photonics, without ext. Exercises neu	6 CR
M-PHYS-103093	Quantum Optics neu	6 CR
M-ETIT-101834	Business Innovation in Optics and Photonics neu	4 CR
M-MACH-101924	Solar Thermal Energy Systems neu	4 CR
M-IDSCHOOLS-103230	German at ID B1.2 neu	4 CR
M-ETIT-103802	Adaptive Optics neu	3 CR
M-ETIT-103450	Digital Signal Processing in Optical Communications – with Practical Exercises neu	6 CR
M-IDSCHOOLS-104603	German at ID A1.1 neu	4 CR
M-IDSCHOOLS-104606	German at ID B2.1 neu	4 CR
M-IDSCHOOLS-104604	German at ID A1.2 neu	4 CR
M-IDSCHOOLS-104605	German at ID A2.2 neu	4 CR
M-IDSCHOOLS-104607	German at ID B2.2 neu	4 CR
M-PHYS-102295	Theoretical Nanooptics neu	6 CR
M-ETIT-103270	Optical Networks and Systems neu	4 CR
M-IDSCHOOLS-105583	German at ID C1.1 neu	4 CR
M-PHYS-104092	Quantum Optics at the Nano Scale: Basics and Applications, with Exercises neu	8 CR
M-PHYS-104094	Quantum Optics at the Nano Scale: Basics and Applications, without Exercises neu	6 CR
M-ETIT-105461	Introduction to Automotive and Industrial Lidar Technology neu	3 CR

2 Modules

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

Responsible: Prof. Dr. Ulrich Lemmer
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

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

Mandatory			
T-ETIT-107644	Adaptive Optics	3 CR	Lemmer

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
Robert K. Tyson, Principles of Adaptive Optics, CRC Press

Michael C. Roggemann, Byron M. Welsh, Imaging through Turbulence, CRC Press

2.2 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
Additional Examinations

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	2 terms	English	4	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 Egyption 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
A. WEST (current edition): Solid State Chemistry and its Applications, Wiley.
A. GREENWOOD, N. EARNSHAW (current edition), Chemistry of the Elements, Elsevier.
U. MÜLLER (current edition): Inorganic Structural Chemistry, Teubner.
J. E. HUHEEY, E. A. KEITER (current edition): Inorganic Chemistry, Pearson.
Selected reviews (as given in the lecture).

M 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

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

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 acquire 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 flourophores,
• 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
Molecular Biology of the Cell, Alberts, B., et al., Taylor & Francis, 6th ed., 2014
Molecular Cell Biology, Lodish, H., et al., Macmillan, 2013

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

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

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 th 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

composed out of

hours of lecture: 15*3 h = 45 h

preparation time prior to and after lecture: 15*5 h = 75 h

exam preparation and exam: 60 h

Learning type
Lecture

Literature
TBA

M 2.5 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	Grading scale	Recurrence	Duration	Language	Level	Version
2	pass/fail	Each summer term	1 term	English	4	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 responsitivity 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.
Essential cell biology, Alberts, B., et al., Taylor & Francis, 4th ed., 2013
Principles of Cell Biology, Plopper, G., Jones & Bartlett Publ., 2011
Prerequisites

M 2.6 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
Additional Examinations

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

- 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?
- Management of Intellectual Property (IP): Importance of IP Management, Patent research, Patent claims, Licencing, Patent infringement, Patent litigation
- 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

M 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

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

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
- "Computational Electro-magnetics: The Finite- Difference Time Domain Method," A. Taflov and S. C. Hagness
- "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]

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

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

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.

M 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

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

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

M 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

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

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, Biot-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
Allen Taflove and Susan Hagness (2000), Computational electrodynamics: the finite-difference time-domain method.
Artech House, Boston, 1-58053-076-1
Nathan Ida and Joao Bastos (1997), Electromagnetics and calculation of fields.
Springer Verlag, New York, 0-387-94877-5
Z. Haznadar and Z. Stih (2000), Electromagnetic Fields, Waves and Numerical Methods.
IOS Press, Ohmsha, 1 58603 064 7
M.V.K. Chari and S.J. Salon (2000), Numerical Methods in Electromagnetism, Academic Press, 0 12 615760 X

M 2.11 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

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

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 technologiccal-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. Characterissation:

- materials properties (electron microscopy, crystallinity, bonding energies, elemeental 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

M 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

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

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-andanswers 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 comunications

The students

- knwo 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 multimode waveguides. Near-field and far-field. Impulse response and transfer function. Perurations and mode coupling. Multimode interference (MMI) coupler. Modal noise (speckle)
- Propagation in homogeneous media: Resolution limit. Non-paracial and paracial optics. Gaussian beam. ABCD matrix
- Coherence of optical fields: Coherence function and power spectrum. Polarisation, eigenstates and principal states. Measurement of coherence with interferometers (Mach-Zehnder, Michelson). Self-heterodyne and self-homodyne setups

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:

Born, M.; Wolf, E.: Principles of optics, 6. Aufl. Oxford: Pergamon Press 1980

Ghatak, A.: Optics, 3. Ed. New Delhi: Tata McGraw Hill 2005

Hecht, E.: Optics, 2. Ed. Reading: Addison-Wesley 1974

Hecht, J.: Understanding fiber optics, 4. Ed. Upper Saddle River: Prentice Hall 2002

Iizuka, K.: Elements of photonics, Vol. I and II. New York: John Wiley & Sons 2002

Further textbooks in German (also in electronic form) can be named on request

M 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

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

Mandatory			
T-PHYS-103630	Fundamentals of Optics and Photonics - Unit	0 CR	Hunger
T-PHYS-103628	Fundamentals of Optics and Photonics	8 CR	Hunger

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 Matrizes; 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 de-monstration 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

M 2.14 Module: Further Examinations [M-ETIT-102000]

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Additional Examinations

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
30	pass/fail	Each term	1 term	German	4	1

M 2.15 Module: German at ID A1.1 [M-IDSCHOOLS-104603]

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

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

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

Mandatory			
T-IDSCHOOLS-109201	German at ID A1.2	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
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

M 2.17 Module: German at ID A2.1 [M-IDSCHOOLS-102357]

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

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

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

M 2.18 Module: German at ID A2.2 [M-IDSCHOOLS-104605]

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

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

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)

M 2.19 Module: German at ID B1.1 [M-IDSCHOOLS-102359]

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

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

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

M 2.20 Module: German at ID B1.2 [M-IDSCHOOLS-103230]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	7

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

M 2.21 Module: German at ID B2.1 [M-IDSCHOOLS-104606]

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

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

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

Mandatory			
T-IDSCHOOLS-110647	German at ID B2.2 - 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 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

M 2.23 Module: German at ID C1.1 [M-IDSCHOOLS-105583]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	German	4	3

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

M 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)
Additional Examinations

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

Mandatory			
T-CHEMBIO-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)
VII. 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

M 2.25 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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
12	pass/fail	Irregular	2 terms	English	5	3

Mandatory			
T-ETIT-105127	Internship Presentation	12 CR	Lemmer, Stiller

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 interns***h***ip 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 team work 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.

M 2.26 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
Additional Examinations

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

Mandatory			
T-ETIT-111011	Introduction to Automotive and Industrial Lidar Technology	3 CR	Stork

Competence Certificate
The examination consists of an oral exam and a short oral presentation. The overall impression is rated.

Competence Goal

- The students are able to explain the basic principles of a lidar sensor
- The students can explain all relevant components of a lidar sensor and put them in context
- The students can explain different forms of execution and make a meaningful choice depending on the requirements
- The students can describe lidar sensors theoretically using the lidar equations and explain the interactions based on this theory
- The students are able to assess the eye safety of a system
- The students are able to suggest possible sensor concepts for different applications or to evaluate existing concepts

Content
In this course the functionality of a lidar sensor is explained and then put into context with relevant use cases. Typical criteria for the evaluation of the performance are then presented. In the following the concept of the sensor is presented in detail and all relevant components are introduced individually. Afterwards they are qualitatively related to each other and the whole system is quantitatively examined by means of the lidar equation. Finally, the interaction of the components is further considered to present meaningful combinations and design solutions. The eye safety of lidar sensors is always explicitly considered. The course concludes with a colloquium in which the students will give short presentations on what they have learned. This repetition is intended to repeat and deepen what has been learned and to lead to a discussion of open question

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)

M 2.27 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

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

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

Competence Certificate
The sucess 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 scientificy?
- 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 x 1,5h = 10,5h
2. preparation of lectures and exercises 7 x 1,5h = 10,5h
3. preparation of the seminar paper: 10h

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

M 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

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

Mandatory			
T-ETIT-100741	Laser Physics	4 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 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)

M 2.30 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	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	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

Simons, Lighting Engineering: Applied Calculations, 2001

Shunsuke Kobayashi: LCD Backlights, 2009

Winchip, Fundamentals of Lighting, 2nd Edition, 2011

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

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

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. Lighting 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
J. Livingstone: Designing With Light: The Art, Science and Practice of Architectural Lighting Design, 2014

S. Russel: The Architecture Of Light: Interior Designer and Lighting Designer, 2012

M. Karlen: Lighting Design Basics, Indoor Lightin, 2004

R.H. Simons Lighting Engineering, 2001Simons, Lighting Engineering: Applied Calculations, 2001

R. Winchip, Fundamentals of Lighting, 2nd Edition, 2011

M 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

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

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 th lecture the participants have gained knowledge on modern techniques of machine vision and pattern recognition which can be used to evaluatecamera images. This especially includes techniques in the areas of gray level image analysis, analysis of color images, segementation 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 disussion 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 valueable 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 developped 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 technqiues 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, omposed 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.

M 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)

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

Mandatory			
T-MACH-103622	Measurement and Control Systems	6 CR	Stiller

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

C. Phillips and R. Harbor: Feedback Control Systems, Prentice-Hall

M 2.34 Module: Modern Physics [M-PHYS-101931]

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

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

Mandatory			
T-PHYS-103629	Modern Physics	6 CR	Pilawa

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 the 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

M 2.35 Module: Module Master's Thesis [M-ETIT-106212]

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

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

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

Competence Certificate
Written thesis and a presentation.

Prerequisites
Prerequisited for the registration of the msater'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 Masther'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 opportunitiy 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.

M 2.36 Module: Molecular Spectroscopy [M-CHEMBIO-101902]

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

Organisation: KIT Department of Chemistry and Biosciences

Part of: Specialization - Quantum Optics & Spectroscopy
Additional Examinations

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

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
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

M 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

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

Mandatory			
T-PHYS-102282	Nano-Optics	8 CR	Naber

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	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	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
R. Boyd. Nonlinear Optics. Academic Press, New York, 1992.
E.H. Li S. Chiang Y. Guo, C.K. Kao. Nonlinear Photonics. Springer Verlag, 2002
G. Agrawal, Nonlinear Fiber Optics, Academic Press, San Diego, 1995.

M 2.39 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

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

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

M 2.40 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
Additional Examinations

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

Mandatory			
T-ETIT-106506	Optical Networks and Systems	4 CR	Randel

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 neetworks: 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 automotion: polymer-optical fiber (POF), MOST Bus, Profibus 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

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

Mandatory			
T-ETIT-106462	Optical Systems in Medicine and Life Science	3 CR	Nahm

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.

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 applicative, 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 Opthalmology and Optometry, Willey-VCH

M 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

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

Mandatory			
T-ETIT-100639	Optical Transmitters and Receivers	6 CR	Freude

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.
Grau, G.; Freude, W.: Optische Nachrichtentechnik, 3. Ed. Berlin: Springer-Verlag 1991. In German. Since 1997 out of print. Electronic version available via w.freude@kit.edu.
Kaminow, I. P.; Li, Tingye; Willner, A. E. (Eds.): Optical Fiber Telecommunications VI A: Components and Subsystems +VI B: Systems and Networks', 6th Ed. Elsevier (Imprint: Academic Press), Amsterdam 2013

M 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

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

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 Marcatili 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 relatons, 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

M 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

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

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.

M 2.45 Module: Optics and Vision in Biology [M-CHEMBIO-101906]

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

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

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 relex and gaze control
• concieve 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 phytochromes 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 phytochromes 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-BMCB.

Attendance to the lecture.

Learning type
Lecture

Literature
ecture presentations are provided in pdf-format
Neuroscience, Purves, D. et al., Sinauer, 2011
Biology, Campbell NA and Reece JB, Prentice Hall International, 2011

M 2.46 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

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

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´sesitivity 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.

Agrawal, G.P.: Lightwave technology. Hoboken: John Wiley & Sons 2004

Iizuka, K.: Elements of photonics. Vol. I, especially Vol. II. Hoboken: John Wiley & Sons 2002

Further textbooks in German (also in electronic form) can be named on request.

M 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)
Additional Examinations

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	English	4	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 photoredoxcatalysis
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
B. König (ed.), Chemical Photocatalysis, De Gruyter, Berlin, 2013.
A. Albini, M. Fagnoni (Hrsg.), Handbook of Synthetic Photochemistry, Wiley-VCH, Weinheim, 2010.
P. Klán, J. Wirz, Photochemistry of Organic Compounds, Wiley, 2009.
N. J. Turro, V. Ramamurthy, J. C. Scaiano, Principles of Molecular Photochemistry, University Science Books, 2009.

M 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

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

Mandatory			
T-ETIT-111896	Photonic Integrated Circuit Design and Applications	6 CR	

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.

M 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

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

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 excersises are held as required in German or English.

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

Recommendation
Knowledge of semiconductor components

Literature
The corresponding documents are available online in the VAB (https://studium.kit.edu/)

M 2.50 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	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-106135	Quantum Optics	6 CR	Rockstuhl

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,
- understands 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*.
- R. Loudon, *The Quantum Theory of Light*.
- D.F. Walls and G. J. Milburn, *Quantum Optics*.
- P. Meystre and M. Sargent, *Elements of Quantum Optics*.
- W. Schleich, *Quantum Optics in Phase Space*.

M 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

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

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 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
- Quantum Optics, M. Scully, M. Suhail Zubairy, Cambridge University Press
- Fundamentals of Photonics, Saleh,Teich
- research articles (will be sent around)

M 2.52 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

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

Mandatory			
T-PHYS-108480	Quantum Optics at the Nano Scale: Bascis and Applications, without Exercises	6 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-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
- Quantum Optics, M. Scully, M. Suhail Zubairy, Cambridge University Press
- Fundamentals of Photonics, Saleh,Teich
- research articles (will be sent around)

M 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

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

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)

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

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

C. Honsberg and S. Bowden, PV Education CD-ROM and website, http://www.pveducation.org/pvcdrom

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

Mandatory			
T-PHYS-104773	Solid-State Optics, without Exercises	8 CR	Hetterich, Kalt

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

2.58 Module: Spectroscopic Methods [M-CHEMBIO-101900]

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

Organisation: KIT Department of Chemistry and Biosciences

Part of: Advanced Optics & Photonics – Methods and Components

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

Mandatory			
T-CHEMBIO-103590	Spectroscopic Methods	3 CR	

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

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

Mandatory			
T-ETIT-100675	Systems and Software Engineering	5 CR	Sax

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	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	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 excercises (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
- J. D. Joannopoulos, S. G. Johnson, J. N. Winn and R. D. Meade, Photonic Crystals: Molding the Flow of Light, University Press

M 2.61 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	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102305	Theoretical Optics - Unit	0 CR	Rockstuhl
T-PHYS-102278	Theoretical Optics	4 CR	Rockstuhl

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)
- Diffraction Theory (The Principles of Huygens and Fresnel, Scalar Diffraction Theory: Green's Function, Helmholtz-Kirchhoff Theorem, Kirchhoff Formulation of Diffraction, Fresnel-Kirchhoff Diffraction Formula, Rayleigh-Sommerfeld Formulation of Diffraction, Angular Spectrum Method, Fresnel and Fraunhofer Diffraction, Method of Stationary Phases, Basics og Holography)
- 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

M 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
Additional Examinations

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

Mandatory			
T-MACH-103624	X-Ray Optics	3 CR	Last

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 Courses

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 22/23	2313724	Adaptive Optics		Lecture / ✕	Gladysz
Exams					
ST 2022	7313724	Adaptive Optics			Lemmer, Gladysz

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

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.

T 3.2 Course: Advanced Inorganic Materials [T-CHEMBIO-103591]

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

Type	Credits	Grading scale	Version
Oral examination	3	Grade to a third	1

Prerequisites
acc. to module catalogue

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	2

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.

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each summer term	2

Events					
ST 2022	2138340	Automotive Vision	3 SWS	Lecture / 🖥	Lauer, Fehler
Exams					
ST 2022	76-T-MACH-105218	Automotive Vision			Stiller, Lauer

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

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:

V Automotive Vision

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

Lecture (V)
Online

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 ßeeing 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.

T 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

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	2	pass/fail	Each summer term	2

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

T 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	4	Grade to a third	Each winter term	1

Events					
WT 22/23	2305742	Business Innovation in Optics and Photonics	2 SWS	Lecture / 🗣	Riedel, Nahm
WT 22/23	2305743	Erxercise for 2305742 Business Innovation in Optics and Photonics	1 SWS	Practice / 🗣	Riedel, Nahm
Exams					
WT 22/23	7305742	Business Innovation in Optics and Photonics			Nahm, Riedel

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.

T 3.7 Course: Computational Photonics, without ext. Exercises [T-PHYS-106131]

Responsible: Prof. Dr. Carsten Rockstuhl
Organisation: KIT Department of Physics
Part of: M-PHYS-103089 - Computational Photonics, without ext. Exercises

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

T 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

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	6	Grade to a third	Each summer term	2

Events					
ST 2022	2309472	Digital Signal Processing in Optical Communications	2 SWS	Lecture / 🗣	Randel
ST 2022	2309473	Digital Signal Processing in Optical Communications (Practical Exercises)	2 SWS	Practice / 🗣	Randel
Exams					
ST 2022	7309472	Digital Signal Processing in Optical Communications – with Practical Exercises			Randel
WT 22/23	7309472	Digital Signal Processing in Optical Communications			Randel

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

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.

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 22/23	2307399	Electric Power Generation and Power Grid	2 SWS	Lecture / 🗣	Hoferer
Exams					
ST 2022	737307399	Electric Power Generation and Power Grid			Hoferer
WT 22/23	7307399	Electric Power Generation and Power Grid			Hoferer

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

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each winter term	1

Events					
WT 22/23	2308263	Electromagnetics and Numerical Calculation of Fields	2 SWS	Lecture / 🗣	Pauli
WT 22/23	2308265	Exercise for 2308263 Electromagnetics and Numerical Calculation of Fields	1 SWS	Practice / 🗣	Pauli, Giroto de Oliveira
Exams					
WT 22/23	7308263	Electromagnetics and Numerical Calculation of Fields			Pauli

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.

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	1

Events					
ST 2022	2313760	Fabrication and Characterization of Optoelectronic Devices	2 SWS	Lecture / 🗣	Paetzold
Exams					
ST 2022	7313760	Fabrication and Characterisation of Optoelectronic Devices			Paetzold
WT 22/23	7313760	Fabrication and Characterisation of Optoelectronic Devices			Paetzold

Legend: 🖥 Online, ✲ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 22/23	2309466	Field Propagation and Coherence	2 SWS	Lecture /	Freude, Maier, Reichenbacher
WT 22/23	2309467	Tutorial for 2309466 Field Propagation and Coherence	1 SWS	Practice /	Freude, N.N.
Exams					
ST 2022	7309466	Field Propagation and Coherence			Freude
WT 22/23	7309466	Field Propagation and Coherence			Freude

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

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	Each winter term	1

Events					
WT 22/23	4044021	KSOP - Fundamentals of Optics & Photonics	4 SWS	Lecture / 🗣	Kalt
WT 22/23	4044022	KSOP - Exercises to Fundamentals of Optics & Photonics	2 SWS	Practice / 🗣	Kalt, Kalt

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.

T 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

Type	Credits	Grading scale	Version
Completed coursework	0	pass/fail	1

Events					
WT 22/23	4044021	KSOP - Fundamentals of Optics & Photonics	4 SWS	Lecture / 🗣	Kalt
WT 22/23	4044022	KSOP - Exercises to Fundamentals of Optics & Photonics	2 SWS	Practice / 🗣	Kalt, Kalt

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	4	Grade to a third	Each winter term	1 terms	3

Events					
WT 22/23	1400001	German at ID A1.1	4 SWS	Lecture / Practice (/	Pangritz
Exams					
WT 22/23	3400001	German at ID A1.1 - exam			Pangritz

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

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each summer term	3

Events					
ST 2022	1400002	German at ID A1.2		Lecture / Practice (/ 🗣	Pangritz
Exams					
ST 2022	3400002	German at ID A1.2 - Exam			Pangritz

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

T 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	4	Grade to a third	Each winter term	1 terms	1

Events					
WT 22/23	1400003	German at ID A2.1	4 SWS	Lecture / Practice (/	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 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

T 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	4	Grade to a third	Each summer term	1 terms	2

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

T 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	4	Grade to a third	Each winter term	1 terms	4

Events					
WT 22/23	1400005	German at ID B1.1	4 SWS	Lecture / Practice (/	Pangritz
Exams					
WT 22/23	3400008	German at ID B1.1 - 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 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.

T 3.20 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	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	4	Grade to a third	Each summer term	1 terms	3

Events					
ST 2022	1400006	German at ID B1.2		Lecture / Practice (/	Pangritz
Exams					
ST 2022	34000010	German at ID B1.2 - 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 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

T 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	4	Grade to a third	Each winter term	1 terms	3

Events					
WT 22/23	1400007	German at ID B2.1	4 SWS	Lecture / Practice (/	Pangritz
Exams					
WT 22/23	3400012	German at ID B2.1 - 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 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

T 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	4	Grade to a third	Each summer term	1 terms	3

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

T 3.23 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Written examination	4	Grade to a third	Each winter term	1 terms	2

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

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each winter term	3

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.

T 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

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	12	pass/fail	Each term	4

Exams			
ST 2022	7390002	Internship	Lemmer, Stiller
ST 2022	7390002-2	Internship	Lemmer, Stiller
WT 22/23	7390002	Internship	Lemmer, Stiller

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 interns***h***ip 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.

T 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

Type	Credits	Grading scale	Recurrence	Expansion	Version
Examination of another type	3	Grade to a third	Each winter term	1 terms	2

Exams			
WT 22/23	7311604	Introduction to automotive and industrial Lidar technology	Stork, Heußner

T 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)

Type	Credits	Grading scale	Recurrence	Expansion	Version
Completed coursework	1	pass/fail	Each term	1 terms	1

Events					
ST 2022	2305745	Introduction to the Scientific Method	1 SWS	Seminar / 🗣	Nahm
WT 22/23	2305746	Introduction to the Scientific Method	1 SWS	Seminar / 🗣	Nahm
Exams					
ST 2022	7305745	Introduction to the scientific method (Seminar, englisch)			Nahm
WT 22/23	7305745	Introduction to the Scientific Method (Seminar, Englisch)			Nahm

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

Competence Certificate
The sucess 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
Detailled information on contents, competence goals, and work load at:
M-ETIT-105665 – Introduction to the Scientific Method (Seminar)

T 3.28 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Events					
ST 2022	2301478	Laser Metrology	2 SWS	Lecture / 🗣	Eichhorn
Exams					
ST 2022	7301478	Laser Metrology			Eichhorn

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Prerequisites
none

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

V Laser Metrology
2301478, SS 2022, 2 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

Content
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 annouced in ILIAS. Exam registration will also be organised via ILIAS.

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 22/23	2301480	Laserphysics	2 SWS	Lecture /	Eichhorn
WT 22/23	2301481	Exercise for 2301480 Laserphysics	1 SWS	Practice /	Eichhorn

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

Prerequisites
none

T 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	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 22/23	2313747	Light and Display Engineering	2 SWS	Lecture / 🗣	Kling
WT 22/23	2313749	Übungen zu 2313747 Light and Display Engineering	1 SWS	Practice / 🗣	Kling
Exams					
ST 2022	7313747	Light and Display Engineering			Kling
WT 22/23	7313747	Light and Display Engineering			Kling

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

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 22/23	2313751	Lighting Design - Theory and Applications	2 SWS	Seminar / 🗣	Kling
Exams					
ST 2022	7313751	Lighting Design - Theory and Applications			Kling
WT 22/23	7313751	Lighting Design - Theory and Applications			Kling

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

Prerequisites
none

T 3.32 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	Each winter term	2

Events					
WT 22/23	2137308	Machine Vision	4 SWS	Lecture / Practice (/	Lauer, Kinzig
Exams					
ST 2022	76-T-MACH-105223	Machine Vision			Stiller, Lauer

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

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:

V Machine Vision

2137308, WS 22/23, 4 SWS, Language: English, Open in study portal

Lecture / Practice (VÜ)
On-Site

Content
Lernziele (EN):

Machine vision (or *computer vision*) describes all kind of techniques that can be used to extract information from camera images in an automated way. Considerable improvements of machine vision techniques throughout recent years, e.g. by the advent of deep learning, have caused growing interest in these techniques and enabled applications in various domains, e.g. robotics, autonomous driving, gaming, production control, visual inspection, medicine, surveillance systems, and augmented reality.

The participants should gain an overview over the basic techniques in machine vision and obtain hands-on experience.

Nachweis: written exam, 60 min.

Arbeitsaufwand: 240 hours

Voraussetzungen: none

Literature
Foliensatz zur Veranstaltung wird als kostenlose pdf-Datei bereitgestellt.Weitere Empfehlungen
werden in der Vorlesung bekannt gegeben.

T 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

Type	Credits	Grading scale	Version
Final Thesis	30	Grade to a third	1

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.

T 3.34 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	2

Events					
WT 22/23	3137020	Measurement and Control Systems	3 SWS	Lecture / 🗣	Stiller
WT 22/23	3137021	Measurement and Control Systems (Tutorial)	1 SWS	Practice / 🗣	Stiller, Fischer, Hauser
Exams					
ST 2022	76-T-MACH-103622	Measurement and Control Systems			Stiller, Pauls
WT 22/23	76-T-MACH-103622	Measurement and Control Systems			Stiller, Pauls

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
oral exam (30 min)

Prerequisites
none

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

V 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 measuremen

Lernhziele (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.H. Cannon: Dynamics of Physical Systems, McGraw-Hill Book Comp., New York,1967
G.F. Franklin: Feedback Control of Dynamic Systems, Addison-Wesley Publishing Company, USA, 1988
R. Dorf and R. Bishop: Modern Control Systems, Addison-Wesley
C. Phillips and R. Harbor: Feedback Control Systems, Prentice-Hall

- 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
Schmidt, G.: Grundlagen der Regelungstechnik, Springer-Verlag, 2. Aufl., 1989

- Messtechnische Bücher:

E. Schrüfer: Elektrische Meßtechnik, Hanser-Verlag, München, 5. Aufl., 1992
U. Kiencke, H. Kronmüller, R. Eger: Meßtechnik, Springer-Verlag, 5. Aufl., 2001
H.-R. Tränkler: Taschenbuch der Messtechnik, Verlag Oldenbourg München, 1996
W. Pfeiffer: Elektrische Messtechnik, VDE Verlag Berlin 1999
Kronmüller, H.: Prinzipien der Prozeßmeßtechnik 2, Schnäcker-Verlag, Karlsruhe, 1. Aufl., 1980

V **Measurement and Control Systems (Tutorial)**
3137021, WS 22/23, 1 SWS, Language: English, Open in study portal

Practice (Ü)
On-Site

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

Type	Credits	Grading scale	Version
Written examination	6	Grade to a third	1

Events					
WT 22/23	4044011	KSOP - Modern Physics	4 SWS	Lecture / 🗣	Pilawa
WT 22/23	4044012	KSOP - Exercises to Modern Physics	2 SWS	Practice / 🗣	Pilawa, NN
Exams					
ST 2022	7800020	Modern Physics (MSc Optics & Photonics, KSOP)			Pilawa

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Written exam (usually about 180 min)

Prerequisites
none

T 3.36 Course: Molecular Spectroscopy [T-CHEMBIO-101864]

Organisation: KIT Department of Chemistry and Biosciences
Part of: M-CHEMBIO-101902 - Molecular Spectroscopy

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	1

Prerequisites
acc. to module catalogue

T 3.37 Course: Nano-Optics [T-PHYS-102282]

Responsible: Dr. Andreas Naber
Organisation: KIT Department of Physics
Part of: M-PHYS-102146 - Nano-Optics

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 22/23	4020021	Nano-Optics	3 SWS	Lecture / 🗣	Naber
WT 22/23	4020022	Exercises to Nano-Optics	1 SWS	Practice / 🗣	Naber

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each summer term	2

Events					
ST 2022	2309468	Nonlinear Optics	2 SWS	Lecture / 🗣	Koos
ST 2022	2309469	Nonlinear Optics (Tutorial)	2 SWS	Practice / 🗣	Koos
Exams					
ST 2022	7309468	Nonlinear Optics			Koos
WT 22/23	7309468	Nonlinear Optics			Koos

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 22/23	2311629	Optical Engineering	2 SWS	Lecture / 🧩	Stork
WT 22/23	2311631	Tutorial for 2311629 Optical Engineering	1 SWS	Practice / 🧩	Vu
Exams					
ST 2022	7311730	Optical Engineering			Stork
WT 22/23	7311629	Optical Engineering			Stork

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

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

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	2

Events					
WT 22/23	2309470	Optical Networks and Systems	2 SWS	Lecture / 🗣	Randel, N.N., Mahmud, Sherifaj
WT 22/23	2309471	Tutorial for 2309470 Optical Networks and Systems	1 SWS	Practice / 🗣	Randel, N.N.
Exams					
ST 2022	7309470	Optical Networks and Systems			Randel
WT 22/23	7309470	Optical Networks and Systems			Randel

Legend: 🖥 Online, ❂ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.41 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each winter term	2

Events					
WT 22/23	2305292	Optical Systems in Medicine and Life Science	2 SWS	Lecture /	Nahm
Exams					
WT 22/23	7305292	Optical Systems in Medicine and Life Science			Nahm

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

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	2

Events					
WT 22/23	2309460	Optical Transmitters and Receivers	2 SWS	Lecture /	Freude, Bremauer, Fang
WT 22/23	2309461	Tutorial for 2309460 Optical Transmitters and Receivers	2 SWS	Practice /	Freude, N.N.
Exams					
ST 2022	7309460	Optical Transmitters and Receivers			Freude
WT 22/23	7309460	Optical Transmitters and Receivers			Freude

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

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 22/23	2309464	Optical Waveguides and Fibers	2 SWS	Lecture / 🗣	Koos, N.N., Bao, Drayß
WT 22/23	2309465	Tutorial for 2309464 Optical Waveguides and Fibers	1 SWS	Practice / 🗣	Koos, N.N.
Exams					
ST 2022	7309464	Optical Waveguides and Fibers			Koos
WT 22/23	7309464	Optical Waveguides and Fibers			Koos

Legend: 🖥 Online, ✲ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.44 Course: Optics and Photonics Lab [T-PHYS-104511]

Responsible: PD Dr. Michael Hetterich
Organisation: KIT Department of Physics
Part of: M-PHYS-102189 - Optics and Photonics Lab

Type	Credits	Grading scale	Version
Completed coursework	10	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

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each winter term	2

Exams			
ST 2022	71KSOP-105198	Optics and Vision in Biology	Weth

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.

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each summer term	1

Events					
ST 2022	2309486	Optoelectronic Components	2 SWS	Lecture / 🗣	Freude
ST 2022	2309487	Optoelectronic Components (Tutorial)	1 SWS	Practice / 🗣	Freude
Exams					
ST 2022	7309486	Optoelectronic Components			Freude
WT 22/23	7309486	Optoelectronic Components			Freude

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.47 Course: Organic Photochemistry [T-CHEMBIO-105195]

Organisation: KIT Department of Chemistry and Biosciences
Part of: M-CHEMBIO-101907 - Organic Photochemistry

Type	Credits	Grading scale	Version
Oral examination	3	Grade to a third	1

Prerequisites

acc. to module catalogue

T 3.48 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

Type	Credits	Grading scale	Version
Examination of another type	6	Grade to a third	1

Events					
ST 2022	2309478	Photonic Integrated Circuit Design and Applications	2 SWS	Lecture / 🔀	Koos, Freude, Randel, Kotz
ST 2022	2309479	Photonic Integrated Circuit Design and Applications (Practical Exercise)	2 SWS	Practical course / 🔀	Koos, Freude, Randel
Exams					
ST 2022	7300005	Photonic Integrated Circuit Design and Applications			Freude, Randel, Koos

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

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.

Prerequisites
none

T 3.49 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Each winter term	1

Events					
WT 22/23	2313709	Polymerelectronics/ Plastic Electronics	2 SWS	Lecture /	Lemmer
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

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	1

Exams			
ST 2022	7800128	Quantum Optics	Rockstuhl

T 3.51 Course: Quantum Optics at the Nano Scale: Bascis 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Events					
ST 2022	4021161	Quantum Optics at the Nano Scale: Fundamentals and Applications	3 SWS	Lecture / 🗣	Hunger

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

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

T 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

Type	Credits	Grading scale	Version
Examination of another type	4	Grade to a third	1

Events					
WT 22/23	4044033	KSOP Research Project	4 SWS	Project (P / 🗣	Kalt

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 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

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Events					
WT 22/23	4044024	KSOP - Seminar Course (3 Courses)	2 SWS	Seminar / 🗣	Hunger, Rosemann

Legend: 🖥 Online, ✨ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 22/23	2313745	Solar Energy	3 SWS	Lecture / 🗣	Richards, Paetzold
WT 22/23	2313750	Tutorial 2313745 Solar Energy	1 SWS	Practice / 🗣	Richards, Paetzold
Exams					
ST 2022	7313745	Solar Energy			Richards, Paetzold
WT 22/23	7313745	Solar Energy			Richards

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).

T 3.56 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	3

Events					
WT 22/23	2189400	Solar Thermal Energy Systems	2 SWS	Lecture / 🗣	Dagan
Exams					
ST 2022	76-T-MACH-106493	Solar Thermal Energy Systems			Dagan

Legend: 🖥 Online, ✲ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
oral exam of about 30 minutes

Prerequisites
none

Recommendation
Literature

1. "Solar Engineering of Thermal Processes", 4th Edition, J. Duffie &W. Beckman. Published by Wiley & Sons
2. “Heat Transfer”, 10th Edition, J. P. Holman Mc. Graw Hill publisher
3. “Fundamentals of classical Thermodynamics”, G. Van Wylen & R. E. Sonntag. Published by Wiley &Sons

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

Lecture (V)
On-Site

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

- “Solar Engineering of Thermal Processes “4th Edition, J. Duffie &W. Beckman. Published by Wiley & Sons.
- “Heat Transfer”, 10th Edition, P. Holman Mc. Graw Hill publisher.
- “Fundamentals of classical Thermodynamics”, G. Van Wylen & R. E. Sonntag. Published by Wiley & Sons

T 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

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	1

Events					
WT 22/23	4020011	Solid-State-Optics	4 SWS	Lecture / 🗣	Hetterich, Kalt
Exams					
WT 22/23	7800104	Solid-State Optics, without Exercises			Kalt, Hetterich

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Prerequisites
none

T 3.58 Course: Spectroscopic Methods [T-CHEMBIO-103590]

Organisation: KIT Department of Chemistry and Biosciences
Part of: M-CHEMBIO-101900 - Spectroscopic Methods

Type	Credits	Grading scale	Version
Written examination	3	Grade to a third	1

Exams			
ST 2022	7100121_2	Spectroscopic Methods Resit	Kappes, Unterreiner
ST 2022	7100121_3	Spectroscopic Methods for Repeaters only	Kappes, Unterreiner
ST 2022	718200121	Spectroscopic Methods	Kappes, Unterreiner

Prerequisites
acc. to module catalogue

T 3.59 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	1

Events					
WT 22/23	2311605	Systems and Software Engineering	2 SWS	Lecture / 🧩	Sax
WT 22/23	2311607	Tutoral for 2311605 Systems and Software Engineering	1 SWS	Practice / 🧩	Nägele
Exams					
ST 2022	7311605	Systems and Software Engineering			Sax
WT 22/23	7311605	Systems and Software Engineering			Sax

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 Technologyis advised

T 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

Type	Credits	Grading scale	Version
Oral examination	6	Grade to a third	1

Events					
WT 22/23	4023131	Theoretical Nanooptics	2 SWS	Lecture / 🗣	Fernandez Corbaton, Rockstuhl
WT 22/23	4023132	Exercises to Theoretical Nanooptics	1 SWS	Practice / 🗣	Fernandez Corbaton, Rockstuhl

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

T 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

Type	Credits	Grading scale	Version
Written examination	4	Grade to a third	1

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.

T 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

Type	Credits	Grading scale	Version
Completed coursework	0	pass/fail	1

Events					
ST 2022	4023111	Theoretical Optics	2 SWS	Lecture / 🗣	Rockstuhl
ST 2022	4023112	Exercises to Theoretical Optics	1 SWS	Practice / 🗣	Rockstuhl, Whittam
Exams					
ST 2022	7800058	Theoretical Optics - Unit			Rockstuhl

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

Prerequisites
none

T 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

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each term	1

Exams			
ST 2022	76-T-MACH-103624	X-Ray Optics	Last
WT 22/23	76-T-MACH-103624	X-Ray Optics	Korvink, Last

Competence Certificate
oral exam

Prerequisites
none