MODULE HANDBOOK

Overview of modules

Lasers and Photonics - Master (1-Fach, PO 2024)

Mandatory modules

Photonics Fundamentals

Optics Fundamentals

Laser Fundamentals

Fundamentals of Quantum Mechanics

Hands-on Fundamentals

English

Master Thesis LAP

Mandatory Electives

Mandatory Elective Courses

Elective Practicals

Elective Practical Courses

Free Elective Courses

Free Elective Courses

Module title: Photonics Fundamentals

Module no./Code	Credits	Workload	Recommended study semester	Cycle	Duration
149265	6 CP	180 h	1. semester (MaLAP)	winter term	1 Semester

Courses / lectures	Contact hour	Self-Study	Group size
141260: Photonics Fundamentals	60 h	120 h	20 Studierende

Language	Requirements
English	none

Responsible person and lecturer(s)
Module coordinator: Prof. Dr. Martin R. Hofmann
Lecturer: Prof. Dr. Martin R. Hofmann

Module use

Master Lasers and Photonics (PO 2024)

Learning outcomes
The students have learned the fundamentals of optical information transfer and retrieval. They have acquired basic knowledge of photonic devices, linear and non-linear optics and understand the concepts of optical telecommunication.

Content
The lecture starts with the fundamentals of electromagnetic theory and of linear optics (refraction, diffraction, dispersion etc.). Afterwards, the interaction of light and matter is analyzed. Photonics devices such as light sources and detectors are discussed. Furthermore, the fundamental principles and applications of non-linear optics are highlighted. As the most important photonic application, optical telecommunications is discussed in detail. The lecture is concluded with an outlook on the potential of photonic crystals and metamaterials.

Teaching type

Lecture with tutorials

Mode of assessment
oral (30 min)
project

Requirements for credits

Successful passing of the module examination.

Proportion of graded modules (based on a required coursework of 120 ECTS)

6/92

Module title: Optics Fundamentals

Module no./Code	Credits	Workload	Recommended study semester	Cycle	Duration
149266	6 CP	180 h	2. semester (MaLAP)	summer term	1 Semester

Courses / lectures	Contact hour	Self-Study	Group size
141259: Optics Fundamentals	60 h	120 h	20 Studierende

Language	Requirements
English	none

Responsible person and lecturer(s)
Module coordinator: Prof. Dr.-Ing. Nils C. Gerhardt
Lecturer: Prof. Dr.-Ing. Nils C. Gerhardt
Dr.-Ing. Carsten Brenner

Module use

Master Lasers and Photonics (PO 2024)

Learning outcomes
Students can explain the basic principles of optical systems and optical imaging by using the classical description of light. They can apply paraxial imaging construction techniques in simple optical systems and present concepts to compensate optical aberrations by using rules of thumb or optical simulations. Students can describe coherence and interference effects and analyze their impact on phase-resolved and 3D imaging. Finally, students can illustrate modern microscopy techniques and compare their characteristics for different application settings.

Content
The course provides an introduction to the fields of classical optics, optical imaging and microscopy. It begins with the basic properties of light and its interaction with matter, including ray optics, wave optics, and Fourier optics. The tools of optical systems, i.e. active and passive optical elements, are then discussed. Another part of the lecture deals with the concept and limitations of optical imaging and discusses optical aberrations and their compensation with the goal of achieving diffraction limited imaging performance. In addition, the course provides a basic understanding of coherent and non-coherent light sources, interferometry and holography, and the use of coherent filtering for optical imaging and metrology. The course concludes with a discussion of classical and super-resolution microscopy techniques in modern optical imaging systems.

Teaching type

Lecture with tutorials

Mode of assessment
oral (30 min)

Requirements for credits
Successful passing of the module examination.

Proportion of graded modules (based on a required coursework of 120 ECTS)

6/92

Module title: Laser Fundamentals

Module no./Code	Credits	Workload	Recommended study semester	Cycle	Duration
149267	6 CP	180 h	2. semester (MaLAP)	summer term	1 Semester

Courses / lectures	Contact hour	Self-Study	Group size
138950: Laser Technology	60 h	120 h	20 Studierende

Language	Requirements
English	none

Responsible person and lecturer(s)
Module coordinator: Prof. Dr.-Ing. Andreas Ostendorf
Prof. Dr. Clara Saraceno
Lecturer: Prof. Dr.-Ing. Andreas Ostendorf
Prof. Dr. Clara Saraceno

Module use

Master Lasers and Photonics (PO 2024)

Learning outcomes
The students learn the principle of lasers and how coherent light is generated. Second, they have learned how these principles are used in different laser sources and how existing lasers are designed. Finally, they have accumulated knowledge of optical components to control and manipulate laser light e.g. to convert wavelengths and to generate short and ultrashort laser pulses. At the end of the lecture the students should be able to design a simple laser system and to build a beam guiding and forming system for different types of lasers.

Content
After an introduction into the different energy levels in atoms and molecules and a basic description of the quantum mechanics concept the different principles of light-matter interaction are derived, i.e. absorption, spontaneous emission and stimulated emission. Second, the rate equations will be presented and effective amplification of light will be discussed. In the following, resonator concepts will be investigated and a complete description of the laser becomes possible. The different laser sources will be presented subdivided into solid-state lasers, gas lasers, liquid dye lasers and semiconductor lasers. Following, short pulse propagation in linear and nonlinear media are discussed in detail and the corresponding effects on the pulses are described. Propagation effects such as solitons are discussed. The second part covers the generation of ultrashort pulses in a laser with modelocking.

Teaching type

Lecture with tutorials

Mode of assessment
oral (30 min)

Requirements for credits
Successful passing of the module examination.

Proportion of graded modules (based on a required coursework of 120 ECTS)

6/92

Module title: Fundamentals of Quantum Mechanics

Module no./Code	Credits	Workload	Recommended study semester	Cycle	Duration
149622	6 CP	180 h	1. semester (MaLAP)	winter term	1 Semester

Courses / lectures	Contact hour	Self-Study	Group size
141478: Fundamentals of Quantum Mechanics	60 h	120 h	20 Studierende

Language	Requirements
English	none

Responsible person and lecturer(s)
Module coordinator: Prof. Dr. Serim Ilday
Lecturer: Prof. Dr. Serim Ilday

Module use

Master Lasers and Photonics (PO 2024)

Learning outcomes
The students will be able to recognize the inadequacy of classical mechanics in describing nature, distinguish phenomena which need the quantum description, explain the connection between real space wavefunctions and probability distribution, solve time-independent Schrödinger equation for one-dimensional simple problems with discrete spectra to find eigenstates and eigenvalues. They will also learn to contrast continuous spectra with discrete spectra through transmission and reflection coefficient calculations, use eigenstate expansion to evaluate the time evolution of observables in simple systems, state the results of a projective measurement in quantum mechanics for the observed values and the wavefunction, compute the energy spectrum of particles in simple three-dimensional potentials including the Hydrogen atom, recognize the Hamiltonian evolution and projective measurements as the basis of quantum phenomena, develop methodologies to attack these cases, perform required operations related to methodologies produce and interpret results related to these problems and discuss how outcomes may be related to present and future technologies.

Content
The course introduces the basic features of quantum mechanics. It covers the experimental basis of quantum physics, introduces wave mechanics, operator and approximation methods in quantum mechanics, harmonic oscillator, path integral formulation of quantum mechanics, systems of many degrees of freedom, Schrödinger’s equation in a single dimension and in three dimensions, spin, atoms and molecules, scattering theory, and quantum theory of electromagnetic radiation.

Teaching type

Lecture with tutorials

Mode of assessment
oral (30 min)

Requirements for credits
Successful passing of the module examination.

Proportion of graded modules (based on a required coursework of 120 ECTS)

6/92

Module title: Hands-on Fundamentals

Module no./Code	Credits	Workload	Recommended study semester	Cycle	Duration
149268	6 CP	180 h	1. and 2. semester (MaLAP)	winter- and summer term	2 Semester

Courses / lectures	Contact hour	Self-Study	Group size
142269: Master Project Optics Fundamentals 142262: Master Project Advanced Optics 1	60 h	120 h	20 Studierende

Language	Requirements
English	none

Responsible person and lecturer(s)
Module coordinator: Prof. Dr. Clara Saraceno
Prof. Dr. Martin Hofmann (LAP coordinator)
Prof. Dr.-Ing. Andreas Ostendorf
Lecturer: Lecturers of the RUB

Module use

Master Lasers and Photonics (PO 2024)

Learning outcomes
The students learn hands-on how to work in optical and laser laboratories, they get hands-on knowledge on measurement methods and data analysis. They also get training on programming geared towards numerical problems encountered lasers and photonics.

Content
Optics Fundamentals

The students prepare material in advance and nine experiments allow them to apply the knowledge in the lab.

The practical experiments are

- the alignment of a single mode fiber coupling setup
- alignment of a Michelson interferometer
- measurements of laser beams and beam quality
- measurements using photodiodes, spectrum analyzers and radio-frequency analyzers
- alignment and use of a Mach Zender interferometer
- use of a Raman spectrometer

The programming tasks are:

- data interpolation
- Fourier transformations
- solving simple differential equations

Further general contents are:

- Cleaning and Handling of optical components
- Optic alignment workflow
- Optomechanical components
- Basic characteristics of lenses and other optics
- Coherence and interference
- Beam quality measurements
- Radio-frequency and optical spectrum analyzers, oscilloscopes

Advanced Optics

The students will work on a topic related to current research activities of the research groups leading the LAP program. Exemplary topics are semiconductor lasers, solid state lasers, ultrashort pulse measurements, spectroscopy, spin-optoelectronics. The project takes place as block course on appointment.

Teaching type

practicals and tutorials

Mode of assessment
Successful practical lab work and programming tasks and presentation of results in oral and/or written form.

Requirements for credits
Successful passing of the module examination.

Proportion of graded modules (based on a required coursework of 120 ECTS)

0/92

Module title: English

Module no./Code	Credits	Workload	Recommended study semester	Cycle	Duration
149264	6 CP	180 h (according to the courses)	1. and 2. semester (MaLAP)	winter- and summer term	2 Semester

Courses / lectures	Contact hour	Self-Study	Group size
251230: English for Specific Academic Purposes: Producing and Presenting a Scientific Poster 251231: English for Specific Academic Purposes: Researching and Writing a Scientific Paper	60 h	120 h	20 Studierende

Language	Requirements
English	none

Responsible person and lecturer(s)
Module coordinator: LAP Coordinator: Prof. Dr. Martin R. Hofmann
Lecturer: Lecturers of the University language centre (ZFA)

Module use

Master Lasers and Photonics (PO 2024)

Learning outcomes
The students acquire competences in the English language. At the end of this module, students will be able to follow lectures in their subject area held in English as well as to participate actively in courses and exercises of their study programme and handle all related tasks and assignments independently. They will have a sound command of the idiom of LAP and thus be able to converse and write in English freely in the scope of study and research in their subject area. They will be capable of expressing concepts and ideas related to this scientific field and thus be equipped for active participation in scientific communication.

Content
In the module English the students first equalise their English language competences and then they learn how to write, present and communicate about their technical and scientifc topics in English. They will receive extensive training in linguistic competencies they need for participation in the Lasers and Photonics study programme. In order to lay the foundation, general language use in academic contexts will be practised. For the development of listening comprehension, authentic lectures will be made available on Blackboard, while introductory texts and sections from textbook articles will serve as the basis for reading comprehension exercises. Speaking will be trained by means of short presentations and discussions in class, and writing skills will be developed mainly through short writing assignments. In the next step, students will receive further training in linguistic competencies necessary for study and research in the field of Lasers and Photonics. The typical idiom of this specific scientific field will be practised both actively and receptively. Speaking will be trained by means of short presentations and discussions in class, and writing skills will be improved mainly through writing assignments as well as contributions to Wikis and Blogs.

Teaching type
language skills training

Mode of assessment
continual assessement: The study progress will be assessed continually and students will be asked to hand in short essays or abstracts and hold short talks about scientifically related topics.

Requirements for credits
Successful passing of the module examination.

Proportion of graded modules (based on a required coursework of 120 ECTS)

0/92

Module title: Master Thesis LAP

Module no./Code	Credits	Workload	Recommended study semester	Cycle	Duration
149280	30 CP	900 h	4. semester (MaLAP)	winter- and summer term	1 Semester

Courses / lectures	Contact hour	Self-Study	Group size
144103: Master Thesis LAP			Studierende

Language	Requirements
English	see examination regulations

Responsible person and lecturer(s)
Module coordinator: LAP Coordinator: Prof. Dr. Martin R. Hofmann
Lecturer: Lectures of the RUB

Module use

Master Lasers and Photonics (PO 2024)

Learning outcomes
The students are familiar with the concepts of scientific research and with the organisation of projects. They are able to present their advanced knowledge and experience in an understandable way.

Content
Mostly self-organised solution of a scientific task under supervision.

Teaching type
master thesis

Mode of assessment
thesis

Requirements for credits
Successful passing of the thesis.

Proportion of graded modules (based on a required coursework of 120 ECTS)

30/92

Module title: Mandatory Elective Courses

Module no./Code	Credits	Workload	Recommended study semester	Cycle	Duration
149621	32 CP	at least 600h (according to the courses)	1.,2., or 3. semester (MaLAP)	winter- and summer term	3 Semester

Courses / lectures	Contact hour	Self-Study	Group size
141271: Biomedical Optics 141367: Electromagnetic Fields 139940: Fiber Optics 141482: Numerical Photonics in Python 141269: Photovoltaics 139230: Techniques of Laser Metrology 139960: Laser Materials Processing 141258: Optical Communications 141267: Optoelectronics 141424: Ultrafast Laser Science and Technology 141425: Mid-Infrared and Terahertz Photonics 138340: Laser Chemistry 141479: Soft Condensed Matter Physics TBD/New: Quantum and Nonlinear Optics TBD/New: Nonlinear and Complex Systems TBD/New: Laser Spectroscopy	see courses		20 Studierende

Language	Requirements
English	none

Responsible person and lecturer(s)
Module coordinator: LAP Coordinator: Prof. Dr. Martin R. Hofmann
Lecturer: Lecturers of the RUB

Module use

Master Lasers and Photonics (PO 2024)

Learning outcomes
The students acquire specific competences in individually chosen special areas of Lasers and Photonics.

Content

The students choose specific topics out of the lecture programme of the participating faculties of the Ruhr-University in order to include an individual focus area into their studies. The courses listed above will be accepted automatically, other choices have to be accepted by the LAP coordinator.

Teaching type

- lecture
- tutorials

Mode of assessment

oral
written

Requirements for credits

Successful passing of the module examination.

Proportion of graded modules (based on a required coursework of 120 ECTS)

32/92

Module title: Elective Practical Courses

Module no./Code	Credits	Workload	Recommended study semester	Cycle	Duration
149620	6 CP	at least 180 h (according to the courses)	1., 2. or 3. semester (MaLAP)	winter- and summer term	3 Semester

Courses / lectures	Contact hour	Self-Study	Group size
142266: Competitive International Research Project Presentation 142265: Competitive International Research Project 143263: Journal Club 141422: Laser Colloquium 142263: Master Project Advanced Optics 2 139040: Master-Project Applied Optics 1 139050: Master-Project Applied Optics 2 143264: Master-Seminar Photonics 143265: Master-Seminar Terahertz Technology 142268: Research Project Conference Participation 142267: Research Project 142264: Science Project	see courses		Studierende

Language	Requirements
English	none

Responsible person and lecturer(s)
Module coordinator: LAP Coordinator: Prof. Dr. Martin R. Hofmann
Lecturer: Lecturers of the RUB

Module use

Master Lasers and Photonics (PO 2024)

Learning outcomes
The students have acquired specific competences in laboratory work and know how to give scientific presentations in the area of Lasers and Photonics. They have learned to find individual solutions to a scientific project and have expertise in scientific communication. They are familiar with different experimental techniques and are able to present a project to a scientific international community. They know how to study actual scientific literature.

Content
The students perform practical courses together in small groups, participate in scientific seminars and give presentations of their work to each other. The detailed content depends on their specific choices between the offered practical courses.

Teaching type

- lecture with integrated tutorials
- colloquium
- project
- seminar

Mode of assessment

lab
seminar
project

Requirements for credits

Successful passing of the module examination.

Proportion of graded modules (based on a required coursework of 120 ECTS)

0/92

Module title: Free Elective Courses

Module no./Code	Credits	Workload	Recommended study semester	Cycle	Duration
149619	16 CP	at least 480 h (according to the courses)	1., 2. or 3. semester (MaLAP)	winter- and summer term	3 Semester

Courses / lectures	Contact hour	Self-Study	Group size
141109: Free Choice	see courses		Studierende

Language	Requirements
English	none

Responsible person and lecturer(s)
Module coordinator: LAP Coordinator: Prof. Dr. Martin R. Hofmann
Lecturer: Lecturers of the RUB

Module use

Master Lasers and Photonics (PO 2024)

Learning outcomes
In this module the students acquire either deeper knowledge of specifc topical areas or new soft skills like, e.g. further languages or economic aspects.

Content
Courses of free choice from the programme of the Ruhr-Universität.

Teaching type
see courses

Mode of assessment
see courses

Requirements for credits
see courses

Proportion of graded modules (based on a required coursework of 120 ECTS)
0/92