RUHR-UNIVERSITÄT BOCHUM

RUB

Masterstudiengang

Lasers and Photonics

PO 15

Module handbook

Department of Electrical Engineering and Information Technology
Fakultät für Maschienenbau

Contents

Chapter 1

Module

1.1 English

number: 149263
responsible person: LAP Coordinator (Prof. Dr. Martin R. Hofmann)
Arbeitsaufwand: 180 Stunden (entsprechend der Lehrveranstaltungen)
Leistungspunkte: 6

Courses:

251230: English for Specific Academic Purposes: Producing and Presenting a Scientific Poster	2 HWS	(S.25)
251231: English for Specific Academic Purposes: Researching and Writing a Scientific Paper	2 HWS	(S.26)

goals: 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 Laser 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.

type of exam: 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.

Stellenwert der Note für die Endnote: 0 / 86

1.2 Free Elective Courses

number: 149271
responsible person: LAP Coordinator (Prof. Dr. Martin R. Hofmann)
Arbeitsaufwand: At least 480 Stunden (entsprechend der Lehrveranstaltungen)
Leistungspunkte: ≥16

Courses:

141109: free choice (S.29)

goals: 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.

type of exam: Examination according to regulations of chosen courses

Stellenwert der Note für die Endnote: 0 / 86

1.3 Laser Materials Processing

number: 149274
responsible person: Priv.-Doz. Dr.-Ing. Cemal Esen
Arbeitsaufwand: 180 Stunden (entsprechend der Lehrveranstaltungen)
Leistungspunkte: 6

Courses:

139960: Laser Materials Processing 4 HWS (S.33)

goals: The students will learn about the basics of the different processing methods. They should be able to estimate benefits and limitations of the different methods and to compare them with conventional production techniques.

content: First of all the principles of different high power lasers and their suitability for material processing are treated. Then the guiding and forming devices for laser beams are discussed. The properties of laser beams and material surfaces are discussed in own chapters. The following chapters include the interaction between laser beam and material as well as the different processing methods e.g. cutting, welding, surface treating and marking. The last two chapters contain an overview about laser safety and an introduction in laser applications in medical engineering.

type of exam: siehe Lehrveranstaltungen

Stellenwert der Note für die Endnote: 6 / 86

1.4 Laser Metrology

number: 149275
responsible person: Prof. Dr.-Ing. Andreas Ostendorf
Arbeitsaufwand: 180 Stunden (entsprechend der Lehrveranstaltungen)
Leistungspunkte: 6

Courses:

139930: Laser Metrology 4 HWS (S.34)

goals: The students have gained knowledge of the principles and opportunities in laser based measurement. They understand the difference between non-coherent and coherent light and how to make use of coherence in interferometry. Third they understand how the different laser measurement principles can be used to measure physical or mechanical parameters.

content: Based on the solution of Maxwells equations the description of electromechanical waves is derived. In this context the important parameters temporal and spatial coherence are defined. Next, Mach-Zehnder and Michelson interferometers are presented and analyzed. In the following recording and reconstruction of holograms is described. By merging the two technologies holographic interferometry is introduced especially for applications in mechanics to analyze oscillations and vibrations. Another important principle is Doppler measurements. After introducing the Doppler-principle and Doppler interferometers/vibrometers Laser Doppler Anemometry (LDA) is presented in more detail. An important chapter in this lecture is also the understanding of important detectors like photodiodes or photomultipliers.

type of exam: siehe Lehrveranstaltungen

Stellenwert der Note für die Endnote: 6 / 86

1.5 Laser Technology

number: 149272
responsible person: Prof. Dr.-Ing. Andreas Ostendorf
Arbeitsaufwand: 180 Stunden (entsprechend der Lehrveranstaltungen)
Leistungspunkte: 6

Courses:

138950: Laser Technology 4 HWS (S.37)

goals: The students understand 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.

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. In the next chapter optical components, polarisation and birefringence are explained and methods to generate short and ultrashort pulses. Based on this knowledge the different laser sources will be presented subdivided into solid-state lasers, gas lasers, liquid dye lasers and semiconductor lasers. Finally, non-linear optics is explained in order to generate new wavelengths.

type of exam: siehe Lehrveranstaltungen

Stellenwert der Note für die Endnote: 6 / 86

1.6 Mandatory Elective Courses

number: 149273
responsible person: Prof. Dr. Martin R. Hofmann
Arbeitsaufwand: At least 600 Stunden (entsprechend der Lehrveranstaltungen)
Leistungspunkte: ≥20

Courses:

141271: Biomedical Optics	2 HWS	(S.17)
184611: Biophysical Chemistry I	4 HWS	(S.18)
141378: Computational Engineering 2: Electrodynamics	2 HWS	(S.21)
141367: Electromagnetic Fields	3 HWS	(S.23)
139940: Fiber Optics	4 HWS	(S.28)
139900: Introduction to Nonlinear optics	2 HWS	(S.30)
160308: Laser Spectroscopy	2 HWS	(S.36)
141482: Numerical Photonics in Python	4 HWS	(S.51)
141269: Photovoltaics	2 HWS	(S.55)
160311: Physics of Quantum Cascade Lasers	3 HWS	(S.56)
139950: Plasmonics	2 HWS	(S.58)
160328: Quantum Optics	4 HWS	(S.59)
141266: Terahertz Technology	4 HWS	(S.66)
141421: Ultrafast Laser Physics 1: Basics of ultrashort pulses	3 HWS	(S.67)
141423: Ultrafast Laser Physics 2: Generation and Applications of Ultrashort Pulses	3 HWS	(S.68)
141420: Ultrafast Laser Physics and Technology	3 HWS	(S.69)

goals: The students acquire specific competences in individually chosen special areas of Lasers and Photonics.

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

type of exam: The module grade is the weighted average of the grades of the individual courses chosen in this module.

Stellenwert der Note für die Endnote: 20 / 86

1.7 Master Thesis LAP

number: 149269
responsible person: LAP Coordinator (Prof. Dr. Martin R. Hofmann)
Arbeitsaufwand: 900 Stunden (entsprechend der Lehrveranstaltungen)
Leistungspunkte: 30

Courses:

144103: Master Thesis LAP (S.39)

goals: 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.

type of exam: A master thesis has to be handed in within the framework of max. 120 pages. A scientific talk has to be given about the results. The Student has to attend five additional scientific talks.

Stellenwert der Note für die Endnote: 30 / 86

1.8 Master-Startup LAP

number: 149877
responsible person: LAP Coordinator (Prof. Dr. Martin R. Hofmann)
Arbeitsaufwand: None Stunden (entsprechend der Lehrveranstaltungen)
Leistungspunkte: 1

Courses:

140008: Master Startup LAP 2 HWS (S.49)

goals: The master startup helps students with any problems concerning studying at RUB. Additionally students should get linked to facilitate co-operation.

content: Information about the master programme, studying at RUB, examination rules, ...

type of exam: This is a voluntary additional course.

Stellenwert der Note für die Endnote: 0 / 86

1.9 Optical Metrology

number: 149276
responsible person: Prof. Dr.-Ing. Nils C. Gerhardt
Arbeitsaufwand: 180 Stunden (entsprechend der Lehrveranstaltungen)
Leistungspunkte: 6

Courses:

141263: Optical Metrology 4 HWS (S.52)

goals: The students understand the physical functional principles of optical metrology. They have learned the characteristics and limits of optical metrology. Furthermore, they got to know the selection criteria of suitable optical measuring techniques for a given application.

content: Optical metrology is used as cross-sectional technology in many disciplines. At first, the basic characteristics of light and its interaction with matter are pointed out in a short fundamental chapter. Subsequently, the tools of optical metrology, i.e. active and passive optical elements are discussed. The main part of the lecture deals with measuring techniques like: geometry measurements, profilometry, shape measurements, spectroscopy, high-speed cameras, infrared imaging, and biophotonics.

type of exam: siehe Lehrveranstaltungen

Stellenwert der Note für die Endnote: 6 / 86

1.10 Optoelectronics

number: 149277
responsible person: Prof. Dr.-Ing. Nils C. Gerhardt
Arbeitsaufwand: 180 Stunden (entsprechend der Lehrveranstaltungen)
Leistungspunkte: 6

Courses:

141267: Optoelectronics 4 HWS (S.53)

goals: Learn the functional principle of optoelectronic devices. Accumulate knowledge of the basic physics and on the function of the most important devices (solar cell, photodiode, light emitting diode, semiconductor laser).

content: At first, the basic principles of semiconductors (lattice structure, band structure, doping) are introduced. In the second chapter, the elementary interactions between light and semiconductors are addressed. The third chapter contains the p-n-junction and hetero junctions. Then, the most important devices: solar cells, photodiodes, light emitting diodes, and semiconductor lasers are discussed in separate chapters. New devices like modulators and optical switches are referred to in the second last chapter and the last chapter consists of an overview about organic optoelectronics.

type of exam: siehe Lehrveranstaltungen

Stellenwert der Note für die Endnote: 6 / 86

1.11 Photonics

number: 149278
responsible person: Prof. Dr. Martin R. Hofmann
Arbeitsaufwand: 180 Stunden (entsprechend der Lehrveranstaltungen)
Leistungspunkte: 6

Courses:

142269: Master Project Optics Fundamentals	1 HWS	(S.44)
141261: Photonics	4 HWS	(S.54)

goals: The students have learned the fundamentals of optical information transfer and retrieval. The have acquired basic knowledge of lasers, linear and non-linear optics and understand the concepts of optical memories (CD, DVD) and optical telecommunication.

content: The lecture starts with the fundamentals of linear optics (refraction, diffraction, dispersion etc.). Afterwards, the interaction of light and matter is analyzed and the fundamentals of lasers are worked out. Important laser systems are discussed and principles of the generation of short light pulses are explained. Furthermore, the principles and applications of non-linear optics are discussed. As the most important photonic application, optical memories and optical telecommunications are discussed in separate chapters. The lecture is concluded with an outlook on the potential of photonic crystals.

type of exam: siehe Lehrveranstaltungen

Stellenwert der Note für die Endnote: 6 / 86

1.12 Practical Subjects

number: 149279
responsible person: Prof. Dr. Martin R. Hofmann
Arbeitsaufwand: At least 180 Stunden (entsprechend der Lehrveranstaltungen)
Leistungspunkte: ≥6

Courses:

142266: Competitive International Research Project Presentation	3 HWS	(S.19)
142265: Competitive International Research Project	2 HWS	(S.20)
143263: Journal Club	2 HWS	(S.31)
141422: Laser Colloquium	2 HWS	(S.32)
142262: Master Project Advanced Optics 1	3 HWS	(S.40)
142263: Master Project Advanced Optics 2	3 HWS	(S.41)
139040: Master-Project Applied Optics 1	3 HWS	(S.42)
139050: Master-Project Applied Optics 2	3 HWS	(S.43)
143261: Master Seminar Biomedical Optics	3 HWS	(S.46)
143264: Master-Seminar Photonics	3 HWS	(S.47)
143265: Master-Seminar Terahertz Technology	3 HWS	(S.48)
141262: Maths for Laser engineers	2 HWS	(S.50)
142268: Research Project Conference Participation	1 HWS	(S.61)
142267: Research Project	3 HWS	(S.62)
142264: Science Project	2 HWS	(S.63)
141270: Scientific Working	2 HWS	(S.64)

goals: 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.

type of exam: siehe Lehrveranstaltungen

Stellenwert der Note für die Endnote: 0 / 86

Chapter 2

Courses

2.1 141271: Biomedical Optics

number: 141271
teaching methods: lecture
media: computer based presentation
black board and chalk
responsible person: Prof. Dr. Martin R. Hofmann
lecturer: Prof. Dr. Martin R. Hofmann
language: english
HWS: 2
Leistungspunkte: 3
angeboten im: winter term

goals: The students have insight into the interaction of light with biomedical tissue. They understand different approaches for optical imaging of biological tissue and know the fundamentals of optical treatment of deseases.

content: The lecture with integrated exercises will cover the fundamentals of light-biological tissue interaction. Instrumentation for biomedical optics will be discussed. The main part of the lecture concerns concepts for imaging biomedical tissue including microscopy and diverse optical tomography approaches. Finally, concepts for treatment of deseases with optical means (e.g. laser surgery) will be presented.

requirements: none

recommended knowledge:

- Modules Photonics and Optical Metrology
- Fundamental knowledge of electromagnetic waves and optics

Arbeitsaufwand: 90 Stunden

Der Arbeitsaufwand berechnet sich wie folgt: 7 Termine je 2 SWS entsprechen in Summe 28 Stunden Präsenszeit. Für die Nachbereitung der Vorlesung und Vorbereitung der Übung sind 42 Stunden erforderlich. 20 Stunden sind zur Vorbereitung auf die Prüfung am Semesterende vorgesehen.

exam: oral, 30 Minuten

literature:

[1] Wang, Lihong V. "Biomedical Optics, Principles and Imaging", Hoboken, 2007

2.2 184611: Biophysical Chemistry I

number: 184611
teaching methods: lecture with tutorials
responsible person: Prof. Dr. Enrica Bordignon
lecturer: Prof. Dr. Enrica Bordignon
language: english
HWS: 4
Leistungspunkte: 5
angeboten im: summer term

goals: Students acquire advanced knowledge of experimental methods and their applications in biophysical chemistry with a focus on structure determining methods.

content:

- Inter- and intramolecular interactions, protein structures: random coil, alpha-helix, beta-sheet
- Methods to unravel secondary, tertiary, and quartery structures: Förster resonance energy transfer (FRET), circular dichroic spectroscopy (CD), infrared and Raman spectroscopies,
- Scattering methods: small angle neutron and x-ray scattering, x-ray crystallography and related non-elastic methods
- static and dynamic light scattering methods
- basic NMR techniques

requirements: none

recommended knowledge: basic knowledge in biophysical chemistry

Arbeitsaufwand: 150 Stunden

The workload is accumulated as follows: 14 weeks with 3 HWS each correspond to a total of 42 hours of physical presence. For preparation of exercises and further reading after the lectures, 4 hours per week are required accumulating to 56 hours. About 52 hours are required in preparation for the examination.

exam: written, 90 Minuten

2.3 142266: Competitive International Research Project Presentation

number: 142266
teaching methods: project
responsible person: LAP Coordinator (Prof. Dr. Martin R. Hofmann)
lecturer: Lecturers of the RUB
language: english
HWS: 3
Leistungspunkte: 3
angeboten im: winter term and summer term

goals:

- Learn international and interdisciplinary communication about a scientific project
- Learn different experimental techniques

content: The student with the supported project in “Competitive International Research Project” travels to the international partner, performs the project and finally presents it to the other students.

requirements: Successful participation in “Competitive International Research Project”

recommended knowledge: Knowledge about presentation of scientific results

Arbeitsaufwand: 90 Stunden

90 hours are required for the 2-3 week international research project and the following presentation

exam: project, continual assessment

description of exam: After the successful evaluation of a proposal in course Competitive International Research Project: practical work in an international laboratory, final presentation in seminar talk in Bochum.

2.4 142265: Competitive International Research Project

number: 142265
teaching methods: project
responsible person: LAP Coordinator (Prof. Dr. Martin R. Hofmann)
lecturer: Lecturers of the RUB
language: english
HWS: 2
Leistungspunkte: 2
angeboten im: winter term and summer term

goals: Learn to write and evaluate scientific proposals.

content: The students define a specific scientific project and identify together with a lecturer an international group where they can work on the project. They write a short scientific proposal about this project. They all meet to constitute the evaluation board which decides which project will be supported.

requirements: none

recommended knowledge: content of at least two obligatory modules

Arbeitsaufwand: 60 Stunden

14 weeks with 2 HWS correspond to 28 hours of physical presence. For writing the proposal further 32 hours are required.

exam: project, continual assessment

description of exam: A project proposal is prepared, an evaluation board is elected and the project proposals are evaluated. The best proposal is selected for support.

2.5 141378: Computational Engineering 2: Electrodynamics

number: 141378
teaching methods: lecture with tutorials
media: computer based presentation
black board and chalk
responsible person: Priv.-Doz. Dr. Jürgen Geiser
lecturer: Priv.-Doz. Dr. Jürgen Geiser
language: english
HWS: 2
Leistungspunkte: 3
angeboten im: winter term

goals:

- Consolidation of the modelling for Maxwell-equations from the lecture Computational Engineering 1
- Preparing the theoretical fundamentals for solving the underlying partial differential equations
- Introduction in grid-dependent methods (Eulerian frame)
- Communication of numerical solver methods for efficient and robust simulations
- Communication of so called coupling methods, e.g., FDTD methods (Finite-Difference Time-Domain methods), which allow to reduce computing time
- Consolidation of the spatial- and time-domain decomposition methods and their parallelisation
- Introduction to commercial and academic simulation programs for solving such electrodynamics equations with focus in code-developping

content:

- Derivation of the hierarchical model-equations for the electrodynamics
- Repetition and consolidation of the numerical methods for the Maxwell-equations (FDTD methods and domain-decomposition methods)
- Basics of the grid-dependent methods (Eulerian frame)
- Parallel methods for spatial- and time-decomposition methods
- Examples in the areas of wave-equation, dipole antenna, fluid- and particle transport
- Extensive practical sessions and programming-exercises in MATLAB and with focus of code-developping

requirements: keine

recommended knowledge:

- Contents of the Modules Mathematics 1-3
- Computational Engineering I (non obligatory required)

Arbeitsaufwand: 90 Stunden

Der Arbeitsaufwand ergibt sich wie folgt: 13 Wochen zu je 2 SWS entsprechen in Summe 28 Stunden Anwesenheit. Für die Nachbereitung der Vorlesung und die Vor- und Nachbereitung der Übungen sind etwa 2 Stunden pro Woche, in Summe 28 Stunden, erforderlich. Etwa 34 Stunden sind für die Prüfungsvorbereitung vorgesehen.

exam: written, 60 Minuten

2.6 141367: Electromagnetic Fields

number: 141367
teaching methods: lecture with tutorials
media: Moodle
computer based presentation
black board and chalk
responsible person: Prof. Dr. Ralf Peter Brinkmann
lecturer: Dr. Denis Eremin
language: english
HWS: 3
Leistungspunkte: 5
angeboten im: summer term

goals: The students learn the theory of electromagnetic fields and waves and are able to apply the techniques to related problems in engineering and physics.

content:

1. Helmholtz theorem
2. General overview of Maxwell's equations. Different approximations: electrostatics, magnetostatics, Darwin
3. Electrostatics: Coulomb's law, Gauss's law
4. Green's function in electrostatics
5. Magnetostatics: Bio-Savart's law, Ampere's law
6. Faraday's law
7. Displacement current, Maxwell's equations, vector and scalar potentials
8. Gauge transformations, Lorenz gauge, Coulomb gauge
9. Energy conservation, Poynting theorem
10. Conservation of linear momentum
11. Plane waves in nonconducting media
12. Properties of electromagnetic waves, polarization
13. Propagation of a wave's packet, phase and group velocity
14. Cylindrical waveguides and cavities
15. TM, TE, and TEM waves
16. Waveguide modes
17. Resonant cavities
18. Green's function for a time-dependent problem in free space
19. Fields and radiation of localized oscillating sources

requirements: None

recommended knowledge: Fundamental knowledge of electromagnetics, partial differential equations, and vector calculus would be helpful.

Arbeitsaufwand: 150 Stunden

The workload is accumulated as follows. 14 weeks with 3 HWS each correspond to a total of 42 hours of physical presence. For preparation of exercises and further reading after the lectures 5 hours per week are required, accumulating to 70 hours. About 38 hours are required for the preparation for the examination.

exam: oral, 30 Minuten

literature:

[1] Jackson, John David "Classical Electrodynamics", Wiley & Sons, 1998
[2] Griffiths, D.J. "Introduction to Electrodynamics", Prentice Hall, 1999
[3] Zangwill, A. "Modern Electrodynamics", Cambridge University Press, 2013
[4] Kendall, P.C. "Vector Analysis and Cartesian Tensors", CRC Press, 1992

2.7 251230: English for Specific Academic Purposes: Producing and Presenting a Scientific Poster

number: 251230
teaching methods: lecture with tutorials
responsible person: LAP Coordinator (Prof. Dr. Martin R. Hofmann)
lecturer: Kara Callahan
language: english
HWS: 2
Leistungspunkte: 3
angeboten im: summer term

goals: The aim of this course is to provide you with the tools and strategies necessary to enable you to speak and write more effectively about your subject area and participate actively in courses, seminars and working groups of your study programme.

Assessment: The course grade will be based on the written and the oral versions of the poster presentation.

content: As in Part 1 of the course (English for academic purposes), students will receive training in all of the language skills (listening, speaking, reading and writing) required for effective participation in the Laser and Photonics master programme.

To this end, we will continue to work on authentic texts relevant to the field of Lasers and Photonics (extracts from textbooks, texts from scientific journals, popular science magazines etc.) to further develop your reading skills and improve your understanding and use of key terminology.

The main focus of the writing component is a poster presentation. Together we will go through the steps necessary to create an authentic scientific poster to present your field of research interest. During a simulated poster presentation session, you will present your research to other students and invited guests.

requirements: none

recommended knowledge: Successful completion of “Lasers and Photonics - English for Academic purposes” (Part 1).

Arbeitsaufwand: 90 Stunden

The workload is accumulated as follows: 14 weeks with 2 HWS each correspond to a total of 28 hours of physical presence. For preparation of exercises and further reading after the lectures, 3 hours per week are required accumulating to 42 hours. About 20 hours are required for preparation of the presentations.

exam: seminar, continual assessment

description of exam: A written exercise in form of, for instance, a scientific paper abstract or a poster presentation has to be accomplished.

2.8 251231: English for Specific Academic Purposes: Researching and Writing a Scientific Paper

number: 251231
teaching methods: language skills training
responsible person: LAP Coordinator (Prof. Dr. Martin R. Hofmann)
lecturer: Kara Callahan
language: english
HWS: 2
Leistungspunkte: 3
angeboten im: winter term

goals: The aim of this course is to provide students with the tools and strategies necessary to enable them to follow lectures in their subject area and participate actively in courses, seminars and working groups of their study programme.

content: Students will receive training in all of the language skills (listening, speaking, reading and, to a lesser extent in English for Engineers, writing) required for effective participation in the Laser and Photonics master programme. In order to develop listening skills and strategies, authentic materials (podcasts, extracts from lectures, video clips etc.) will be used in class and also made available on the Blackboard e-learning platform as home assignments. Additionally, students will learn a variety of note-taking strategies for lectures. Authentic texts relevant to the field of Lasers and Photonics (extracts from textbooks, texts from scientific journals, popular science magazines etc.) will be used to develop students' reading skills and improve their understanding and use of key terminology. Speaking skills will be improved by means of short presentations on students' specific areas of interest and class discussions on issues raised by the reading and listening texts. Scientific writing skills will be introduced through short guided writing assignments. Students who successfully complete the course English for Engineers may attend the course Technical English in the Summer Term 2013.

requirements: none

recommended knowledge: This course requires prior knowledge of English, equivalent to at least level B1 CEFR (Common European Framework of Reference for Languages) or the following bands/scores in standardised language certificates: IELTS 4.0, TOEFL IBT 70, TOEFL CBT 175, TOEFL PBT 505 or PET (Preliminary English Test).

Arbeitsaufwand: 90 Stunden

The workload is accumulated as follows: 14 weeks with 2 HWS each correspond to a total of 28 hours of physical presence. For preparation of exercises and further reading after the lectures, 3 hours per week are required accumulating to 42 hours. About 20 hours are required for preparation of the presentations.

exam: seminar, continual assessment

description of exam: An oral presentation has to be held at the end of the first term.

2.9 139940: Fiber Optics

number: 139940
teaching methods: lecture with tutorials
responsible person: Priv.-Doz. Dr.-Ing. Cemal Esen
lecturer: Dr.-Ing. Thomas Weigel
language: english
HWS: 4
Leistungspunkte: 6
angeboten im: winter term

goals: The students will be acquiring advanced knowledge on properties, preparation, and applications of optical fibers.

content: First of all an introduction in the basics of optics is given. The properties, preparation methods and components for fiber coupling are discussed in own chapters. In following chapters the application of optical fibers in optical communication, as sensing devices and as fiber lasers are discussed. The last chapter contains an introduction in photonic crystal fibers.

requirements: none

recommended knowledge: basic knowledge in engineering, physics and mathematics

Arbeitsaufwand: 180 Stunden

The workload is accumulated as follows. 14 weeks with 4 HWS corresponding to a total of 56 hours of classes. For preparation of exercises and further reading beside the lectures 6 hours per week are required, accumulating to 84 hours. About 40 hours are required for the preparation for the examination.

exam: oral, 30 Minuten

literature:

[1] Mitschke, Fedor "Fiber Optics: Physics and Technology", None, 2009
[2] Bures, Jacques "Guided Optics", Wiley-VCH, 2008

2.10 141109: free choice

number: 141109
teaching methods: arbitrary
responsible person: LAP Coordinator (Prof. Dr. Martin R. Hofmann)
lecturer: Lecturers of the RUB
language: english
angeboten im: winter term and summer term

goals: Within these courses module the students add individual focus areas to their studies. For that purpose they can choose from the whole course programme of the Ruhr-Universität in order to improve their knowledge either in areas related to the topic Lasers and Photonics or to other areas like, for example, languages, economy, philosophy and others.

content: The choice of appropriate courses can be made out of all courses of the Ruhr-Universität. This includes lectures of all faculties and the programme of the Center for Foreign Language Education (Zentrum für Fremdsprachenausbildung, ZFA). Even the choice of courses of the Technical University Dortmund is possible due to a contract of both universities.

requirements: corresponding to the chosen courses

recommended knowledge: corresponding to the chosen courses

exam: oral, continual assessment

description of exam: the exam mode can vary according to selected courses

2.11 139900: Introduction to Nonlinear optics

number: 139900
teaching methods: lecture with integrated tutorials
responsible person: Prof. Dr. rer. nat. Evgeny Gurevich
lecturer: Prof. Dr. rer. nat. Evgeny Gurevich
language: english
HWS: 2
Leistungspunkte: 3
angeboten im:

goals: Get idea about nonlinear optics and understand design and applications of ultrashort (picosecond and femtosecond) lasers.

content: The lecture course starts with an introduction to nonlinear physics and bifurcation theory. Such topics as bifurcations, synchronization and chaos in laser systems are discussed. These topics are also illustrated with other examples from optics and laser technology as well as from everyday's life. Special attention is paid to applications of the nonlinear effects like mode synchronization and self-focussing to generation of ultrashort light pulses. Further, design and operation of ultrashort lasers are discussed. Properties and applications of femtosecond lasers are compared to continuous wave and nanosecond ones.

requirements: none

recommended knowledge: basics about laser technology

Arbeitsaufwand: 90 Stunden

The workload is accumulated as follows: 14 weeks with 2 HWS each correspond to a total of 28 hours of physical presence. For the preparation of exercises and further reading after the lectures, 3 hours per week are required, accumulating to 42 hours. About 20 hours are required in preparation for the examination.

exam: oral, 30 Minuten

2.12 143263: Journal Club

number: 143263
teaching methods: seminar
responsible person: LAP Coordinator (Prof. Dr. Martin R. Hofmann)
lecturer: Lecturers of the RUB
language: english
HWS: 2
Leistungspunkte: 2
angeboten im: winter term

goals: Learn to study actual scientific literature, to extract the essential information from a scientific publication and to present it in a short own talk.

content: The students meet in a seminar. Under guidance of the lecturers they study the actual scientific literature and search for information about a specific topic in the area of Lasers and Photonics. They extract the essential information out of the literature, prepare a short scientific talk and present it to the other students.

requirements: none

recommended knowledge: content of at least two obligatory modules

Arbeitsaufwand: 60 Stunden

The workload is accumulated as follows. 14 weeks with 2 SWS each correspond to a total of 28 hours of physical presence. For further reading and preparation of the presentations further 32 hours are required.

exam: seminar, continual assessment

description of exam: Analysis and presentation of current research topics from scientific international journals.

2.13 141422: Laser Colloquium

number: 141422
teaching methods: colloquium
responsible person: Prof. Dr. Clara J. Saraceno
lecturer: Prof. Dr. Clara J. Saraceno
language: english
HWS: 2
Leistungspunkte: 2
angeboten im: winter term and summer term

goals:

- Broaden knowledge on laser technology and applications
- Follow a presentation by an external speaker, identify most important content during the presentation
- Do individual research on one of the topics presented
- Presentation skills: learn how to summarize a scientific presentation orally

content: The laser colloquium consists of a weekly event, where renowned speakers from academia and industry eill present an advanced introduction to their research areas. The goal is to get acquainted with various ‘hot‘topics around laser technology.

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requirements: None

recommended knowledge: None

Arbeitsaufwand: 60 Stunden

Der Arbeitsaufwand berechnet sich wie folgt: 7 Termine je 2 SWS entsprechen in Summe 28 Stunden Präsenszeit. Für die Nachbereitung der Vorlesung und Vorbereitung der Übung sind 32 Stunden erforderlich.

exam: seminar, continual assessment

2.14 139960: Laser Materials Processing

number: 139960
teaching methods: lecture with tutorials
responsible person: Priv.-Doz. Dr.-Ing. Cemal Esen
lecturer: M. Sc. Henrik Dobbelstein
language: english
HWS: 4
Leistungspunkte: 6
angeboten im: summer term

goals: The students will learn about the basics of the different processing methods. They should be able to estimate benefits and limitations of the different methods and to compare them with conventional production techniques.

content: First of all the principles of different high power lasers and their suitability for material processing are treated. Then the guiding and forming devices for laser beams are discussed. The properties of laser beams and material surfaces are discussed in own chapters. The following chapters include the interaction between laser beam and material as well as the different processing methods e.g. cutting, welding, surface treating and marking. The last two chapters contain an overview about laser safety and an introduction in laser applications in medical engineering.

requirements: none

recommended knowledge:

- basic knowledge in mathematics, physics, and engineering
- basics of materials, heat transfer, manufacturing engeneering

Arbeitsaufwand: 180 Stunden

The workload is accumulated as follows. 14 weeks with 4 HWS corresponding to a total of 56 hours of classes. For preparation of exercises and further reading beside the lectures 6 hours per week are required, accumulating to 84 hours. About 40 hours are required for the preparation for the examination.

exam: oral, 30 Minuten

literature:

[1] Schaaf, Peter "Laser Processing of Materials - Fundamentals, Applications and Developments", Springer, 2010
[2] Iffländer, Reinhard "Solid-State Lasers for Materials Processing", Springer, 2001

2.15 139930: Laser Metrology

number: 139930
teaching methods: lecture with integrated tutorials
media: computer based presentation
black board and chalk
responsible person: Prof. Dr.-Ing. Andreas Ostendorf
lecturer: Prof. Dr.-Ing. Andreas Ostendorf
language: english
HWS: 4
Leistungspunkte: 6
angeboten im: winter term

goals: The students have gained knowledge of the principles and opportunities in laser based measurement. They understand the difference between non-coherent and coherent light and how to make use of coherence in interferometry. Third they understand how the different laser measurement principles can be used to measure physical or mechanical parameters.

content: Based on the solution of Maxwells equations the description of electromechanical waves is derived. In this context the important parameters temporal and spatial coherence are defined. Next, Mach-Zehnder and Michelson interferometers are presented and analyzed. In the following recording and reconstruction of holograms is described. By merging the two technologies holographic interferometry is introduced especially for applications in mechanics to analyze oscillations and vibrations. Another important principle is Doppler measurements. After introducing the Doppler-principle and Doppler interferometers/vibrometers Laser Doppler Anemometry (LDA) is presented in more detail. An important chapter in this lecture is also the understanding of important detectors like photodiodes or photomultipliers.

requirements: none

recommended knowledge:

- Basic knowledge of physics, mathematics and engineering
- Basics in electrical engineering

Arbeitsaufwand: 180 Stunden

The workload is accumulated as follows. 14 weeks with 4 HWS each correspond to a total of 56 hours of physical presence. For preparation of excercises and further reading after the lectures 6 hours per week are required, accumulating to 84 hours. About 40 hours are required for the preparation for the examination.

exam: oral, 30 Minuten

literature:

[1] Kreis, Thomas "Handbook of Holographic Interferometry: Optical and Digital Methods", Wiley-VCH, 2004
[2] Yoshizawa, Toru "Handbook of Optical Metrology: Principles and Applications", CRC Press, 2009

2.16 160308: Laser Spectroscopy

number: 160308
teaching methods: lecture with tutorials
responsible person: Prof. Dr. Daniel Hägele
lecturer: Prof. Dr. Daniel Hägele
language: english
HWS: 2
Leistungspunkte: 3
angeboten im:

goals: The lecture deepens the understanding of light matter interaction beyond the absolute basics (absorption, refractive index, gain) using examples from atomic and semiconductor physics. The knowledge of physical limits of measurement techniques will help the students to judge and plan experimental setups.

content: Time-resolved pump-probe spectroscopy, photoluminescence spectroscopy, application of non-linear optics for second harmonic light generation, polarized light, notions of light matter interaction, optical selection rules, optical spin selection rules, optical shot noise, quantum limits of precision measurements, elimination of noise sources in optical measurement setups

requirements: none

recommended knowledge:

- Basic knowledge of electrodynamics and quantum mechanics, some mathematics
- Quantum mechanics of the hydrogen atom and the harmonic oscillator.

Arbeitsaufwand: 90 Stunden

14 weeks with 2 HWS correspond to 28 hours of physical presence. Further reading and exercises require 3 hours a week. 20 hours are necessary for the exam preparation.

exam: written, 120 Minuten

literature:

[1] Demtröder, W. "Laser Spectroscopy. Basic Concepts and Instrumentation",
Springer, 2003

2.17 138950: Laser Technology

number: 138950
teaching methods: lecture with tutorials
media: computer based presentation
black board and chalk
responsible person: Prof. Dr.-Ing. Andreas Ostendorf
lecturer: Prof. Dr. rer. nat. Evgeny Gurevich
language: english
HWS: 4
Leistungspunkte: 6
angeboten im: summer term

goals: The students understand 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.

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. In the next chapter optical components, polarisation and birefringence are explained and methods to generate short and ultrashort pulses. Based on this knowledge the different laser sources will be presented subdivided into solid-state lasers, gas lasers, liquid dye lasers and semiconductor lasers. Finally, non-linear optics is explained in order to generate new wavelengths.

requirements: none

recommended knowledge:

- Theoretical electrical engineering
- basic knowledge of physics, mathematics and engineering

Arbeitsaufwand: 180 Stunden

The workload is accumulated as follows. 14 weeks with 4 HWS each correspond to a total of 56 hours of physical presence. For preparation of excercises and further reading after the lectures 6 hours per week are required, accumulating to 84 hours. About 40 hours are required for the preparation for the examination.

exam: oral, 30 Minuten

literature:

[1] Silfvast, William "Laser Fundamentals", Cambridge University Press, 1996
[2] Siegmann, Anthony "Lasers", University Science Books, 1986
[3] Koechner, Walter "Solid-State Laser Engineering", Springer, 2006

2.18 144103: Master Thesis LAP

number: 144103
teaching methods: master thesis
responsible person: LAP Coordinator (Prof. Dr. Martin R. Hofmann)
lecturer: Lecturers of the RUB
language: english
Leistungspunkte: 30
angeboten im: winter term and summer term

goals: 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. Participation in 5 talks about results of master theses in LAP. Presentation of own results within a scientific talk.

requirements: see examination regulations

recommended knowledge: corresponding to the chosen issue

Arbeitsaufwand: 900 Stunden

6 month full time

exam: thesis, continual assessment

description of exam: individual starting date

2.19 142262: Master-Project Advanced Optics 1

number: 142262
teaching methods: project
responsible person: Prof. Dr. Martin R. Hofmann
Lecturers: Prof. Dr. Martin R. Hofmann
Prof. Dr. Clara J. Saraceno
language: english
HWS: 3
Leistungspunkte: 3
angeboten im: summer term

goals: The students have gained practical experience in handling optoelectronic elements. Learn the basics of optical spectroscopy.

content: It will be worked on a topic related to current research activities. Exemplary topics are semiconductor lasers, spectroscopy and spin-optoelectronics. The project takes place as block course on appointment.

requirements: none

recommended knowledge:

- fundamental knowledge of optics and optoelectronics
- attendance of a laser safety instruction is mandatory

Arbeitsaufwand: 90 Stunden

The workload is accumulated as follows: 14 weeks with 3 HWS each correspond to a total of 42 hours of physical presence. For preparation of exercises and further reading after the lectures, 3 hours per week are required accumulating to 42 hours. About 6 hours are required in preparation for an oral presentation.

exam: project, continual assessment

description of exam: Participation in laboratory block course, preparation of project report and presentation of results in 15 min. seminar talk.

2.20 142263: Master-Project Advanced Optics 2

number: 142263
teaching methods: project
responsible person: Prof. Dr. Martin R. Hofmann
lecturer: Prof. Dr. Martin R. Hofmann
language: english
HWS: 3
Leistungspunkte: 3
angeboten im: winter term

goals: The students have gained practical experience in optical metrology and in handling optical instruments.

content: It will be worked on a topic related to current research activities. Exemplary topics are holography, interferometry and short pulse generation. The project takes place as block course on appointment.

requirements: none

recommended knowledge:

- fundamental knowledge of optics
- attendance of a laser safety instruction (the date will be announced) is mandatory

Arbeitsaufwand: 90 Stunden

The workload is accumulated as follows: 14 weeks with 3 HWS each correspond to a total of 42 hours of physical presence. For preparation of exercises and further reading after the lectures, 3 hours per week are required accumulating to 42 hours. About 6 hours are required in preparation for an oral presentation.

exam: project, continual assessment

description of exam: Participation in laboratory block course, preparation of project report and presentation of results in 15 min. seminar talk.

2.21 139040: Master-Project Applied Optics 1

number: 139040
teaching methods: project
responsible person: Priv.-Doz. Dr.-Ing. Cemal Esen
lecturer: Anton Saetchnikov
language: english
HWS: 3
Leistungspunkte: 3
angeboten im: winter term

goals: The students have gained practical experience in optical metrology and in handling optical instruments.

content: It will be worked on a topic related to current research activities. Exemplary topics are holography, interferometry and short pulse generation. The project takes place as block course on appointment.

requirements: none

recommended knowledge:

- fundamental knowledge of optics
- attendanca of a laser safety instruction (e.g. Monday 21st Oct, 11:00h ID 05/158) is mandatory

Arbeitsaufwand: 90 Stunden

The workload is accumulated as follows: 14 weeks with 3 HWS each correspond to a total of 42 hours of physical presence. For preparation of exercises and further reading after the lectures, 3 hours per week are required accumulating to 42 hours. About 6 hours are required in preparation for an oral presentation.

exam: project, continual assessment

2.22 139050: Master-Project Applied Optics 2

number: 139050
teaching methods: project
responsible person: Prof. Dr. rer. nat. Evgeny Gurevich
lecturer: Prof. Dr. rer. nat. Evgeny Gurevich
language: english
HWS: 3
Leistungspunkte: 3
angeboten im: summer term

goals: The students have gained practical experience in optical metrology and in handling optical instruments.

content: It will be worked on a topic related to current research activities. Exemplary topics are holography, interferometry and short pulse generation. The project takes place as block course on appointment.

requirements: none

recommended knowledge:

- fundamental knowledge of optics and optoelectronics

Arbeitsaufwand: 90 Stunden

The workload is accumulated as follows: 14 weeks with 3 HWS each correspond to a total of 42 hours of physical presence. For preparation of exercises and further reading after the lectures, 3 hours per week are required accumulating to 42 hours. About 6 hours are required in preparation for an oral presentation.

exam: project, continual assessment

2.23 142269: Master-Project Optics Fundamentals

number: 142269
teaching methods: project
responsible person: Prof. Dr. Martin R. Hofmann
lecturer: Prof. Dr. Martin R. Hofmann
language: english
HWS: 1
Leistungspunkte: 1
angeboten im: winter term and summer term

goals: After the project the students understand

- the basic requirements for work in an optical laboratory
- basic Matlab commands for data analysis (esp. interpolation and Fourier transform)

Furthermore the students are able to apply

- the gained knowledge of optical experiments concerning the handling and alignment of optics
- simple data analysis tasks using Matlab

content: The students receive information material about the fundamental work flow in optical laboratories and data analysis in Matlab. In three experiments the gained knowledge of the students is tested and futhermore applied to two optical setups and some data.

The practical experiments are the alignment of a single mode fiber coupling setup and a Michelson interferometer. In the Matlab experiment data interpolation and Fourier transform are in the focus of the exercise.

Further contents are:

- Cleaning and Handling of optical components
- Optic alignment workflow
- Optomechanical components
- Basic characteristics of lenses and other optics
- Coherence and interferference

requirements: none

recommended knowledge: none

Arbeitsaufwand: 30 Stunden

The workload is accumulated as follows: 14 weeks with 1 HWS each correspond to a total of 14 hours of physical presence. For preparation of exercises and further reading after the lectures, 1 hours per week are required accumulating to 14 hours. About 2 hours are required in preparation for an oral presentation.

exam: project, continual assessment

2.24 143261: Master-Seminar Biomedical Optics

number: 143261
teaching methods: seminar
responsible person: Prof. Dr. Martin R. Hofmann
lecturer: Prof. Dr. Martin R. Hofmann
language: english
HWS: 3
Leistungspunkte: 3
angeboten im:

goals: The students have learned how to investigate and deal with scientific information while acquiring presentation techniques. They have gained knowledge of current research activities of optical measurement techniques for biomedical applications.

content: Exemplary topics are optical coherence tomography, confocal microscopy, fluorescence spectroscopy etc.

requirements: none

recommended knowledge: fundamental knowledge of optics

Arbeitsaufwand: 90 Stunden

The workload is accumulated as follows: 14 weeks with 3 HWS each correspond to a total of 42 hours of physical presence. 48 hours are required in preparation for the own oral presentation.

exam: seminar, continual assessment

2.25 143264: Master-Seminar Photonics

number: 143264
teaching methods: seminar
responsible person: Prof. Dr. Martin R. Hofmann
lecturer: Prof. Dr. Martin R. Hofmann
language: english
HWS: 3
Leistungspunkte: 3
angeboten im: winter term

goals:

- The students have learned how to investigate and deal with scientific information while acquiring presentation techniques.
- They have gained knowledge of current research activities of photonic systems and techniques.

content: Exemplary topics are:

- Laser systems
- Optical communication
- Photonic systems
- etc.

requirements: none

recommended knowledge: Fundamental knowledge of optics.

Arbeitsaufwand: 90 Stunden

The workload is accumulated as follows: 14 weeks with 3 HWS each correspond to a total of 42 hours of physical presence. 48 hours are required in preparation for the own oral presentation.

exam: seminar, continual assessment

2.26 143265: Master-Seminar Terahertz Technology

number: 143265
teaching methods: seminar
responsible person: Prof. Dr. Martin R. Hofmann
lecturer: Prof. Dr. Martin R. Hofmann
language: english
HWS: 3
Leistungspunkte: 3
angeboten im: summer term

goals:

- The students have learned how to investigate and deal with scientific information while acquiring presentation techniques.
- They have gained knowledge of current research activities of THz technology.

content: Exemplary topics are:

- THz sources
- THz systems
- THz spectroscopy
- etc.

requirements: none

Arbeitsaufwand: 90 Stunden

The workload is accumulated as follows: 14 weeks with 3 HWS each correspond to a total of 42 hours of physical presence. 48 hours are required in preparation for the own oral presentation.

exam: seminar, continual assessment

2.27 140008: Master-Startup LAP

number: 140008
teaching methods: arbitrary
responsible person: LAP Coordinator (Prof. Dr. Martin R. Hofmann)
lecturer: M. Sc. Navina Kleemann
language: english
HWS: 2
Leistungspunkte: 1
angeboten im: winter term and summer term

goals: The master startup helps students with any problems concerning studying at RUB. Additionally students should get linked to facilitate co-operation.

content: Information about the master programme, studying at RUB, examination rules, ...

Arbeitsaufwand: 30 Stunden

This is a voluntary additional course.

exam: None, continual assessment

2.28 141262: Maths for Laser engineers

number: 141262
teaching methods: lecture with integrated tutorials
media: black board and chalk
responsible person: LAP Coordinator (Prof. Dr. Martin R. Hofmann)
lecturer: Dipl.-Inform. Martin Benning
language: english
HWS: 2
Leistungspunkte: 2
angeboten im: winter term and summer term

goals: The participants understand the basic mathematical concepts for laser engineers and are able tp apply them. They are able to apply Matlab for data analysis and simple simulations.

content:

1. Mathematical Fundamentals

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   - Important functions (sin, cos, exp, In, ...)
   - Complex numbers
   - Differentiation, Integration
   - Differential equations
   - Fourier transformation
   - Statistics

2. Informatics

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   - Exercises with Matlab

requirements: None

recommended knowledge: None

Arbeitsaufwand: 60 Stunden

The workload is accumulated as follows: 15 weeks with 2 HWS each correspond to a total of 30 hours of physical presence. For preparation of exercises and further reading after the lectures, 1,5 hours per week are required accumulating to 22,5 hours. About 7,5 hours are required in preparation for the examination.

exam: lab, continual assessment

2.29 141482: Numerical Photonics in Python

number: 141482
teaching methods: lecture with tutorials
media: e-learning
responsible person: Prof. Dr. Clara J. Saraceno
lecturer: Dr. Martin Saraceno
language: english
HWS: 4
Leistungspunkte: 5
angeboten im: winter term

goals: The goal is to use the Python programming language to solve common every-day tasks that arise in Photonics. Solving problems using programming is the main focus of the lecture and all tasks will require it.

content:

- brief overview of the Python programming language
- Fourier Transformation
- characterization of ultrashort pulses
- propagation of ultrashort pulses
- solving differential equations
- Gaussian beam propagation and cavity stability
- optical coatings

requirements: None

recommended knowledge: A good knowledge of a modern programming language is highly recommended. The basics of programming in Python will be covered at the beginning, but without any knowlegde of programming, this lecture can be considered to be very hard. Fundamentals of optics and a thorough mathematics background are recommended.

Arbeitsaufwand: 150 Stunden

The workload is accumulated as follows: 14 weeks with 4 HWS each correspond to a total of 56 hours of physical presence. For the preparation of exercises and further reading after the lectures, 4 hours per week are required, accumulating to 56 hours. About 38 hours are required in preparation for the examination.

exam: project, continual assessment

2.30 141263: Optical Metrology

number:	141263
teaching methods:	lecture with tutorials
media:	computer based presentation black board and chalk
responsible person:	Prof. Dr.-Ing. Nils C. Gerhardt
Lecturers:	Prof. Dr.-Ing. Nils C. Gerhardt Dr.-Ing. Carsten Brenner
language:	english
HWS:	4
Leistungspunkte:	6
angeboten im:	summer term

goals: The students understand the physical functional principles of optical metrology. They have learned the characteristics and limits of optical metrology. Furthermore, they got to know the selection criteria of suitable optical measuring techniques for a given application.

content: Optical metrology is used as cross-sectional technology in many disciplines. At first, the basic characteristics of light and its interaction with matter are pointed out in a short fundamental chapter. Subsequently, the tools of optical metrology, i.e. active and passive optical elements are discussed. The main part of the lecture deals with measuring techniques like: geometry measurements, profilometry, shape measurements, spectroscopy, high-speed cameras, infrared imaging, and biophotonics.

requirements: none

recommended knowledge: Fundamental knowledge of electromagnetic waves and optics

Arbeitsaufwand: 180 Stunden

The workload is accumulated as follows: 14 weeks with 4 HWS each correspond to a total of 52 hours of physical presence. For preparation of exercises and further reading after the lectures, 6 hours per week are required accumulating to 84 hours. About 44 hours are required in preparation for the examination.

exam: oral, 30 Minuten

literature:

[1] Saleh, , Teich, "Fundamentals of Photonics", Wiley & Sons, 2007

2.31 141267: Optoelectronics

number: 141267
teaching methods: lecture with tutorials
media: computer based presentation
responsible person: Prof. Dr.-Ing. Nils C. Gerhardt
lecturer: Prof. Dr.-Ing. Nils C. Gerhardt
language: english
HWS: 4
Leistungspunkte: 6
angeboten im: winter term

goals: Learn the functional principle of optoelectronic devices. Accumulate knowledge of the basic physics and on the function of the most important devices (solar cell, photodiode, light emitting diode, semiconductor laser).

content: At first, the basic principles of semiconductors (lattice structure, band structure, doping) are introduced. In the second chapter, the elementary interactions between light and semiconductors are addressed. The third chapter contains the p-n-junction and hetero junctions. Then, the most important devices: solar cells, photodiodes, light emitting diodes, and semiconductor lasers are discussed in separate chapters. New devices like modulators and optical switches are referred to in the second last chapter and the last chapter consists of an overview about organic optoelectronics.

requirements: none

recommended knowledge:

- Basic knowledge of engineering, physics and mathematics
- Quantum mechanics

Arbeitsaufwand: 180 Stunden

The workload is accumulated as follows: 14 weeks with 4 HWS each correspond to a total of 56 hours of physical presence. For preparation of exercises and further reading after the lectures, 6 hours per week are required accumulating to 84 hours. About 40 hours are required in preparation for the examination.

exam: oral, 30 Minuten

2.32 141261: Photonics

number: 141261
teaching methods: lecture with tutorials
media: computer based presentation
black board and chalk
responsible person: Prof. Dr. Martin R. Hofmann
lecturer: Prof. Dr. Martin R. Hofmann
language: english
HWS: 4
Leistungspunkte: 5
angeboten im: summer term

goals: The students have learned the fundamentals of optical information transfer and retrieval. The have acquired basic knowledge of lasers, linear and non-linear optics and understand the concepts of optical memories (CD, DVD) and optical telecommunication.

content: The lecture starts with the fundamentals of linear optics (refraction, diffraction, dispersion etc.). Afterwards, the interaction of light and matter is analyzed and the fundamentals of lasers are worked out. Important laser systems are discussed and principles of the generation of short light pulses are explained. Furthermore, the principles and applications of non-linear optics are discussed. As the most important photonic application, optical memories and optical telecommunications are discussed in separate chapters. The lecture is concluded with an outlook on the potential of photonic crystals.

requirements: none

recommended knowledge: Fundamental knowlegde of electromagnetic waves

Arbeitsaufwand: 150 Stunden

Der Arbeitsaufwand ergibt sich wie folgt: 14 Wochen zu je 4 SWS entsprechen in Summe 56 Stunden Anwesenheit. Für die Nachbereitung der Vorlesung und die Vor- und Nachbereitung der Übungen sind etwa 4 Stunden pro Woche, in Summe 56 Stunden, erforderlich. Etwa 38 Stunden sind für die Klausurvorbereitung vorgesehen.

exam: oral, 30 Minuten

literature:

[1] Saleh, , Teich, "Fundamentals of Photonics", Wiley & Sons, 2007
[2] Meschede, Dieter "Optics, Light and Lasers", Wiley-VCH, 2007
[3] Jahns, Jürgen "Photonik. Grundlagen, Komponenten und Systeme", Oldenbourg, 2001

2.33 141269: Photovoltaics

number: 141269
teaching methods: lecture with integrated tutorials
responsible person: Prof. Dr. Martin R. Hofmann
lecturer: Dr.-Ing. Dietmar Borchert
language: english
HWS: 2
Leistungspunkte: 3
angeboten im: winter term

goals: The students have acquired basic knowledge of photovoltaics and learned the fundamentals of solar cells and photovoltaic systems.

content: Content overview: - The sun as energy source - Basics of semiconductor physics - Operating principle of a solar cell - Solar cell materials - Production technologies - Cell concepts - Module technology - Grid connected systems - Stand-alone PV systems

requirements: none

recommended knowledge: basics about electronic materials and devices

Arbeitsaufwand: 90 Stunden

The workload is accumulated as follows: 14 weeks with 2 HWS each correspond to a total of 28 hours of physical presence. For the preparation of exercises and further reading after the lectures, 3 hours per week are required, accumulating to 42 hours. About 20 hours are required in preparation for the examination.

exam: written, 90 Minuten

2.34 160311: Physics of Quantum Cascade Lasers

number: 160311
teaching methods: lecture with tutorials
media: computer based presentation
black board and chalk
responsible person: Dr. Nathan Jukam
lecturer: Dr. Nathan Jukam
language: english
HWS: 3
Leistungspunkte: 4
angeboten im: winter term

goals: This course will cover the physics necessary to understand quantum cascade lasers. Quantum cascade lasers are a new class of semiconductor lasers that are based on intersubband transitions. They emit radiation at mid-infrared and far-infrared wavelengths. This is in contrast to conventional diode semiconductor lasers which are based on interband transitions and emit radiation at visible and near-infrared wavelengths. The active region of a quantum cascade laser consists of repeating series (cascades) of quantum wells and barriers that are grown in Molecular Beam Epitaxy (MBE) or Metal Organic Vapor Deposition (MOCVD) machines. In order to achieve lasing, wavefunctions and levels should be designed to maximize / (minimize) the lifetime of the upper / (lower) laser level, reduce parasitic scattering, maximize injection into the upper laser level, and minimize losses. This requires a thorough understanding of the optical properties of twodimensional semiconductors, and electron transport and scattering in semiconductor heterostructures.

In addition to these topics, the course will review basic laser theory, survey different types of waveguides, and give an introduction to interband diode lasers.

content: Basic Laser theory spontaneous emission, stimulated emission, absorption, Einstein A and B coefficients, Rate equations, 3 and 4 level laser systems, laser threshold, gain clamping / saturation, homogeneous and inhomogeneous broadening, multi-mode and single mode lasers, spatial hole burning, longitudinal and transverse modes, spontaneous emission noise and laser line width, frequency pulling, Q-switching, mode-locking line width, different types of lasers.

Wave functions and effective mass: Review of tight binding model, nearly free-electron model, and the formation of bands. Bloch's theorem, envelope approximation, effective mass approximation, hetero-structure effective mass theory - modifications of the continuity conditions and the kinetic operator in the envelope approximation

Idealized potentials parabolic well, infinite square well, finite square well, finite heterostructure square well, superlattices and minibands, Bloch oscillations, coupled quantum wells, Stark effect

Refinements of effective mass theory: k dot p method, Kane 2 and 3 band models, nonparabolicity, Luttinger parameters

Optical properties of quantum wells: Interband, and intraband transitions, absorption in quantum wells, selection rules, oscillator strength – sum rules, depolarization shift, gain and loss, modification of sum rules and transition dipole moments from non-parabolicity

QCL design strategies: two-dimensional rate equations, slope efficiency, importance of lifetimes, parasitic scattering, Bragg confinement, resonant tunneling (qualitative treatment), backfilling and self-heating, bound-to-continuum designs, LO-phonon designs, chirped supper-lattice and phase space designs.

Resonant tunneling injection and extraction: coupled quantum wells, resonant tunneling diodes, density matrix - two and three-level models, coherent and incoherent transport regimes, scattering assisted injection, electric field domains

Carrier scattering: phonon scattering, electron-electron scattering, impurity scattering, interface roughness, elevated electron temperatures

Conventional diode lasers: pn junction injection, electron-hole recombination, quasi -fermi levels, quantum well laser, quantum dot lasers, VCSELs, DFB lasers, diode laser rate equations, relaxation oscillations and frequency chirp, line-width enhancement factor

Waveguides / mode confinement: TE and TM modes, dielectric slab waveguides, surface plasmon waveguides, photonic crystals, distributed brag reflectors, mode coupling, orthogonality / completeness of modes, mode overlap factor

Applications/methods: vibrational spectroscopy, mode control, frequency locking, wavelength tuning in a Littrow configuration, injection seeding and locking

requirements: none

recommended knowledge: A course in Quantum Mechanics (at the level of Shankar) and Electromagnetism is required. An introductory course in solid state physics is highly desirable, but is not required.

Arbeitsaufwand: 120 Stunden

The workload is accumulated as follows: 14 weeks with 3 HWS each correspond to a total of 42 hours of physical presence. For the preparation of exercises and further reading after the lectures, 4 hours per week are required, accumulating to 56 hours. About 22 hours are required in preparation for the examination.

exam: oral, 30 Minuten

2.35 139950: Plasmonics

number: 139950
teaching methods: lecture
responsible person: Prof. Dr. rer. nat. Evgeny Gurevich
lecturer: Dr. Thibault Derrien
language: english
HWS: 2
angeboten im:

goals: Get an intuition and basic knowledge in plasmonics, an active field with applications in electromagnetics, photonics and chemistry.

content: Plasmons are coherent oscillations of electrons happening at the surface and in the volume of materials.

The lecture starts with an introduction of possible applications of plasmonics, and introduces the fundamentals using the classical theory of electromagnetics. Derivation of possible electromagnetic modes at the interface of materials and in nanoparticles will be presented, along with the study of Mie scattering theory. Emphasis will be put on the importance of taking damping into account which is now necessary to progress in this field. An overview of the future of plasmonics, and the link with quantum mechanics will be also mentioned for curiosity.

requirements: none

recommended knowledge: Electrodynamics and basic knowledge about differential equations.

exam: written, 120 Minuten

2.36 160328: Quantum Optics

number: 160328
teaching methods: lecture with tutorials
media: Moodle
responsible person: Dr. Nathan Jukam
lecturer: Dr. Nathan Jukam
language: english
HWS: 4
Leistungspunkte: 4
angeboten im: summer term

goals: This course will cover the physics necessary to understand quantum cascade lasers. Quantum cascade lasers are a new class of semiconductor lasers that are based on intersubband transitions.

content: Review of Quantum Mechanics: harmonic oscillator, ladder operators, Hermitian conjugate, Hermitian operators, Dirac notation, Schrödinger picture, Heisenberg picture and Interaction picture.

Quantization of the electro-magnetic field: creation and annihilation operators, quadrature operators, coherent states and the displacement operator.

Light-matter interactions: Rabi oscillations, bare and dressed states, decoherence, strong and weak coupling, Jaynes-Cummings model, atomic collapse and revivals, Purcell effect.

Single photon interference in Mach-Zehnder interferometers: symmetric and asymmetric beam splitters, entangled and product states, interaction free measurements.

First and second order correlation functions: single photon sources, chaotic light, coherent light, anti-bunched light, super-Poissonian, Poissonian and Sub-Poissonian statistics.

Mathematical equivalence of spin 1/2 and two-level systems: magnetic resonance, Bloch sphere, rotating frame, spin echoes.

Collections of two-level systems: superradiance, Dicke states, collective quasi-spin operators, fermionic enhancement of vacuum Rabi oscillations.

Three-level "lambda" systems: adiabatic population inversion, electro-magnetic induced transparency, slow light.

Squeezed states: uncertainty relations, squeezing operator, degenerate parametric down conversion.

requirements: None

recommended knowledge: Previous course in Quantum Mechanics.

Arbeitsaufwand: 120 Stunden

Der Arbeitsaufwand ergibt sich wie folgt: 14 Wochen zu je 4 SWS entsprechen in Summe 56 Stunden Anwesenheit. Für die Nachbereitung der Vorlesung und die Vor- und Nachbereitung der Übungen sind etwa 3 Stunden pro Woche, in Summe 56 Stunden, erforderlich. Etwa 22 Stunden sind für die Klausurvorbereitung vorgesehen.

exam: written, 180 Minuten

2.37 142268: Research Project Conference Participation

number: 142268
teaching methods: project
responsible person: LAP Coordinator (Prof. Dr. Martin R. Hofmann)
lecturer: Lecturers of the RUB
language: english
HWS: 1
Leistungspunkte: 1
angeboten im: winter term and summer term

goals:

- Learn to present a scientific project to a scientific international community

content: The students prepare a short scientific talk. Preferentially, they submit it to a conference and present it to an international audience.

requirements: Accepted scientific talk in “Research Project”

recommended knowledge: Knowledge of how to present scientific results

Arbeitsaufwand: 30 Stunden

30 hours accumulate for preparing and presenting the contribution if the conference submission is accepted.

exam: project, continual assessment

description of exam: The results from the course Research Project is presented at an international conference.

2.38 142267: Research Project

number: 142267
teaching methods: project
responsible person: LAP Coordinator (Prof. Dr. Martin R. Hofmann)
lecturer: Lecturers of the RUB
language: english
HWS: 3
Leistungspunkte: 3
angeboten im: winter term and summer term

goals:

- Learn different experimental techniques
- Learn to present scientific results

content: The students work together in small groups. They receive individual specific scientific experimental tasks from one of the lecturers and work on it in the laboratory. Finally they prepare a short scientific talk which may be submitted and presented at a conference (see Research Project Conference Patricipation).

requirements: none

recommended knowledge: content of at least two obligatory modules

Arbeitsaufwand: 90 Stunden

14 weeks with 2 HWS correspond to 28 hours of physical presence. Further reading and exercises require 3 hours a week. 20 hours are necessary for the exam preparation.

exam: project, continual assessment

description of exam: Participation in laboratory block course, preparation of project report and presentation of results in 15 min. seminar talk. An abstract about the results is submitted to a conference.

2.39 142264: Science Project

number: 142264
teaching methods: project
responsible person: LAP Coordinator (Prof. Dr. Martin R. Hofmann)
lecturer: Lecturers of the RUB
language: english
HWS: 2
Leistungspunkte: 4
angeboten im: winter term

goals: Learn to find individual solutions to a scientific project. Learn scientific communication. Learn different experimental techniques.

content: The students work together in small groups. They receive a specific scientific task from one of the lecturers. Then they work on a strategy for an experimental solution of this task, discuss this strategy with the lecturers and organise the experimental work that is required with the groups and laboratories which can contribute relevant expertise to the solution of the task. Finally, they prepare a short scientific talk and present it to the other students.

requirements: none

recommended knowledge: content of at least two obligatory modules

Arbeitsaufwand: 120 Stunden

The workload is accumulated as follows. 14 weeks with 2 HWS each correspond to a total of 28 hours of physical presence. For planning the strategy and the organisation of the project, further 56 hours are required. Finally, further 36 hours are required for evaluation of the data and preparation of a presentation.

exam: project, continual assessment

description of exam: A scientific problem is defined together with a LAP lecturer. A strategy to solve this problem is developed at own initiative, laboratory experiments are performed independently. Finally, a project report is prepared and the results are presented in a 15 min. seminar talk.

2.40 141270: Scientific Working

number: 141270
teaching methods: lecture with tutorials
media: computer based presentation
responsible person: Prof. Dr. Martin R. Hofmann
lecturer: Dr.-Ing. Carsten Brenner
language: english
HWS: 2
Leistungspunkte: 2
angeboten im:

goals: The students learn to know and understand the basic facts about the scientific work and the effective communication of the achieved results. Furthermore they are able to apply this knowledge in short assessments.

content: The target audience for this lecture are Bachelor students during their third term to help with the necessary background for research activities. Furthermore it gives an impression of the requirements during master studies or a PhD project.

The three main chapters are:

1. Background

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   - What is science
   - Scientific structures
   - Quality criteria

2. Effective Communication and Tools

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   Enumerated list ends without a blank line; unexpected unindent. backrefs:

   - Oral communication and presentation tools
   - Written communication and word processors
   - Graphs and data analysis tools

3. Scientific Process

   [system-message] [system-message]system-message
   WARNING/2 in <string>, line 16
   Enumerated list ends without a blank line; unexpected unindent. backrefs:

   - Defining the problem
   - Doing the work
   - Plan and write the report / thesis

requirements: none

recommended knowledge: none

Arbeitsaufwand: 60 Stunden

The workload is accumulated as follows: 14 weeks with 2 HWS each correspond to a total of 28 hours of physical presence. For preparation of exercises and further reading after the lectures, 2 hours per week are required accumulating to 28 hours. About 4 hours are required in preparation for the examination.

exam: project, continual assessment

literature:

[1] Doumont, Jean-luc "Trees, maps, and theorems", Principia, 2009
[2] Heesen, Bernd "Wissenschaftliches Arbeiten", Springer, 2014
[3] Balzert, Helmut, Schäfer, Christian, Schröder, Marion "Wissenschaftliches Arbeiten, 2. Auflage", W3l, 2011

2.41 141266: Terahertz Technology

number: 141266
teaching methods: lecture with integrated tutorials
media: computer based presentation
black board and chalk
responsible person: Prof. Dr. Martin R. Hofmann
lecturer: Dr.-Ing. Carsten Brenner
language: english
HWS: 4
Leistungspunkte: 4
angeboten im:

goals: The students have insight into the electromagnetic spectrum in the region from 100 GHz to 30 THz. They understand the different approaches for the generation and the detection of THz radiation.

content: For a long time the generation of THz radiation was a major issue. In the past 20 years the possible approaches to generation and detection of THz radiation have evolved. The lecture gives an overview over radiation in this spectral region and its possible applications. Main focus of the lecture are concepts for THz generation that are based on optical principles (quantum cascade lasers, gas and pulse lasers) as well as electronic means (mixers, tunnel diodes, superconducting contacts). Special attention is paid to time domain spectroscopy which has become a commercially available technology in the past few years.

requirements: none

recommended knowledge: Fundamental knowledge of electromagnetic waves and optics

Arbeitsaufwand: 120 Stunden

The workload is accumulated as follows: 14 weeks with 3 HWS each correspond to a total of 42 hours of physical presence. For the preparation of exercises and further reading after the lectures, 4 hours per week are required, accumulating to 56 hours. About 22 hours are required in preparation for the examination.

exam: oral, 30 Minuten

literature:

[1] Xu, Jingzhou, Zhang, X.-C. ”Introduction to THz Wave Photonics”, Springer, 2010
[2] Lee, Yun-Shik ”Principles of Terahertz Science and Technology”, Springer, 2009
[3] Murphy, J. Anthony, O’Sullivan, Créidhe ”Terahertz Sources, Detectors, and Optics”, Spie Press, 2012
[4] Bründermann, Erik, Hübers, Heinz-Wilhelm, Kimmitt, Maurice FitzGerald ”Terahertz Technologies”, Springer, 2012

2.42 141421: Ultrafast Laser Physics 1: Basics of ultrashort pulses

number: 141421
teaching methods: lecture with tutorials
responsible person: Prof. Dr. Clara J. Saraceno
lecturer: Prof. Dr. Clara J. Saraceno
language: english
HWS: 3
Leistungspunkte: 4
angeboten im: winter term

goals: Become familiar with the description and measurements of ultrashort pulses in the time and frequency domain. Learn how ultrashort pulses are affected by propagation through linear and nonlinear media.

content: Pulse description, linear and nonlinear propagation (dispersion, self-phase modulation, self-focusing, etc.), soliton propagation, carrier-envelope phase, measurement techniques.

requirements: None

recommended knowledge: Electromagnetics, Fourier transformations

Arbeitsaufwand: 120 Stunden

The workload is accumulated as follows: 14 weeks with 3 HWS each correspond to a total of 42 hours of physical presence. For the preparation of exercises and further reading after the lectures, 4 hours per week are required, accumulating to 56 hours. About 22 hours are required in preparation for the examination.

exam: written, 120 Minuten

2.43 141423: Ultrafast Laser Physics 2: Generation and Applications of Ultrashort Pulses

number:	141423
teaching methods:	lecture with tutorials
media:	handouts computer based presentation black board and chalk
responsible person:	Prof. Dr. Clara J. Saraceno
Lecturers:	Prof. Dr. Clara J. Saraceno Dr. Denizhan Koray Kesim Dr. Frank Wulf
language:	english
HWS:	3
Leistungspunkte:	4
angeboten im:	summer term

goals: Become familiar with the techniques of modelocking and amplification to generate ultrashort pulses, and get an overview of the latest state-of-the art in ultrafast laser technology and their applications.

content: Active and Passive modelocking in solid state lasers, fiber laser modelocking and amplification, use of ultrashort pulses in science and industry.

requirements: Ultrafast Laser Physics 1: Basics of ultrashort pulses

recommended knowledge: Electromagnetics, Fourier transformations. It is also recommended to have taken the first part of the lecture “Basics of ultrashort pulses”.

Arbeitsaufwand: 120 Stunden

The workload is accumulated as follows: 14 weeks with 3 HWS each correspond to a total of 42 hours of physical presence. For the preparation of exercises and further reading after the lectures, 4 hours per week are required, accumulating to 56 hours. About 22 hours are required in preparation for the examination.

exam: oral, 30 Minuten

2.44 141420: Ultrafast Laser Physics and Technology

number: 141420
teaching methods: lecture
media: computer based presentation
black board and chalk
responsible person: Prof. Dr. Clara J. Saraceno
lecturer: Prof. Dr. Clara J. Saraceno
language: english
HWS: 3
Leistungspunkte: 4
angeboten im:

goals: The students understand how to generate, manipulate and characterize ultrashort laser pulses, and they are familiar with most recent technological developments in ultrafast laser technology.

content: The course will cover the following topics:

- Linear and nonlinear propagation of optical pulses
- Dispersion compensation
- Modelocking and amplification of ultrashort pulses
- Ultrashort pulse measurement techniques
- New trends in ultrafast lasers

requirements: none

recommended knowledge:

- Fundamental knowledge of electromagnetic waves, optics, Fourier analysis
- Ideally the students have completed the Laser Technology and/or the Photonics mandatory courses.

Arbeitsaufwand: 120 Stunden

The workload is accumulated as follows: 14 weeks with 3 HWS each correspond to a total of 42 hours of physical presence. For the preparation of exercises and further reading after the lectures, 4 hours per week are required, accumulating to 56 hours. About 22 hours are required in preparation for the examination.

exam: oral, 30 Minuten