Module Catalog for PO 2017

Study Guide for the study program
Optical Technologies
Bachelor of Science
Master of Science

academic year 18/19
Impressum
Hannover Centre for Optical Technologies of the Leibniz Universität Hannover
www.hot.uni-hannover.de

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Dear Students,

Hereby, you receive the current module catalogue of the Master Course “Optical Technologies”. This course was established by the Faculty of Mechanical Engineering as well as the Faculty of Mathematics and Physics in cooperation with the Laser Zentrum Hannover e.V. in order to strengthen and promote the field of optical technologies in science and research in Hannover.

With this new master course you receive an education, which combines cutting edge basic and applied research in the fields of optics and photonics, physics and engineering and thus qualifies you for both the optics industries and academic research. In combination with your educational background - Bachelor of Science or Bachelor of Engineering – you acquire skills to apply scientific theory in research practice.

If required, the Office of Student Affairs supports you in planning and organizing your study. Do not hesitate to make use of this possibility. Furthermore, you will receive support from experienced students, scientific staff members of the institutes and the Hannover Centre for Optical Technologies (HOT).

We wish you the best for your studies,

Prof. Dr.-Ing. Stephan Kabelac
Dean of studies of the faculty of mechanical engineering.

Prof. Dr. habil. Bernhard Roth
Scientific and managing director, Hannover Centre for Optical Technologies (HOT).
Master’s degree program Optical Technologies

The standard period of study is four semesters of which one semester is for the master thesis. Overall, 120 credit points (CP) are to be achieved, which are split into the following individual modules:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic courses</td>
<td>20 CP</td>
</tr>
<tr>
<td>Optional courses</td>
<td>35 CP</td>
</tr>
<tr>
<td>Master Lab</td>
<td>5 CP</td>
</tr>
<tr>
<td>Studium Generale and Tutorials</td>
<td>4 CP</td>
</tr>
<tr>
<td>Student Project</td>
<td>10 CP</td>
</tr>
<tr>
<td>Internship (12 weeks)</td>
<td>15 CP</td>
</tr>
<tr>
<td>Master Thesis</td>
<td>30 CP</td>
</tr>
</tbody>
</table>

Study profile

The master’s degree program has the goal to train professionals and executives for the entire optics industry with a focus on “German Agenda Optical Technologies for the 21st Century”.

On the national scale, Lower Saxony is already well positioned in the teaching of optics and photonics. Favorable conditions are specifically given in Hanover as a particularly close cooperation between the basic disciplines engineering and physics is well established. Furthermore, the Laser Zentrum Hannover constitutes a link between academic research and industry to involve the industrial partners in the current research and science and introduces academic students to the industry.

This interdisciplinary master's degree program is not primarily associated with only one faculty but combines the fundamental skills of the Faculty of Mathematics and Physics with the application knowledge of engineering.

Educational goals of the master's degree course optical technologies – Knowledge, Skills, Competence

It is expected from the future professionals in optics and photonics to not only be able to solve tasks and problems on the basis of engineering methods but also to have knowledge on the important basic principles of optical technologies.

This is ensured by corresponding compulsory courses offered in the master’s Degree program. The theoretical and practical training in physics is completed with specific topics in engineering, which can be selected from different competence areas. Practical training in the context of laboratory tests and an internship in an industrial area prepares the students for their professional activity in research based companies of the optical industry.

In addition, the Student Project and the master thesis help students to acquire skills for the independent handling of projects. Gaining experience in the planning and implementation of projects and the transfer of knowledge for the preparation of a proper project documentation and presentation of the project results are also among the primary objectives of this work. Building on the physical and engineering skills taught during the courses, the graduates are empowered to solve tasks and problems in the field of optical technologies. A target matrix of the master's degree program can be found in the appendix.

Didactic results

Graduates of the master’s degree program will acquire a broad knowledge in the field of optical technologies. Thus, the program teaches knowledge, skills and methods, which, due to the faculties' high proportion of research, represent the state-of-the-art in optics and photonics. Due to the internship in the field of industry, practical laboratory work as well as Student Project and master thesis, experience in project management, teamwork and scientific care in research activities can be gained.

Studium Generale

The Studium Generale serves the extra-professional qualification of the students. All courses at Leibniz University are recognized as part of this module. Courses for the student’s native language as well as language courses below the course requirements are not credited.
**Master Lab**

The objective of the master lab is the practical application and consolidation of the theoretical knowledge gained in the attended lectures and exercises. The master lab includes experiments in mechanical engineering and physics but also in the fields of computer science and electrical engineering.

Several practical experiments are carried out, which are managed by the participating institutes. Although under supervision, the tests are carried out independently by student teams. Dates and registration details will be announced by the respective institutes. For organization and further information please contact lehre@hot.uni-hannover.de.

**Tutorial**

Tutorials are used for conveying of key competences. Most tutorials include approximately 25 hours of attendance time or self-study time, corresponding to a 3-day seminar. Skills are taught in the fields of scientific research, media presentation, self and team organization, or the handling of scientific software.

The tutorial program will be expanded continuously. It can be picked up in the office of the dean of the faculty of mechanical engineering as either print or pdf version. Dates and registration details will be announced by the respective institutes.

**Student Project**

In the Student Project, students learn to work with a scientific task independently. From literature research to problem solving and subsequent presentation, the students will be introduced to working in the scientific field. The project requires a processing time of 300 hours. This corresponds to approximately 7.5 40h-weeks.

**Initial Internship**

The Initial Internship enables students to gain their first experience of industry. Within a working environment of experts, students, teachers and technical personnel, the student is able to develop practical knowledge of varied manufacturing processes and facilities.

The Initial Internship lasts 8 weeks and may be combined with the Advanced Internship. If applicable, internships already completed or previous vocational training or activity may be credited. Further details are defined by the Internship Regulations and the Internship Office of the Faculty.

**Advanced Internship**

The Advanced Internship prepares students for the productive cooperation in research based companies in the optical industry and in companies of other industries that use optics for quality control in the production or as part of a total product.

During the internship, the focus is laid on work which is closely related to the field of engineering within a development team or a research and development area. Usually, the student receives a subtask which he will work on, document, and present after proper training in the course of the internship.

The Advanced Internship lasts twelve weeks. Internships already completed can be credited. Further details are defined by the Internship Regulations and the Internship Office of the Faculty. In the case of previously completed internship, courses in the area of elective and elective courses with a total volume of 15 CP must be taken instead.

**Master Thesis**

The students have the opportunity to participate in an international research environment, and to work on a relevant scientific problem independently in accordance with a project plan developed by them. This includes the execution of respective experiments and calculations as well as the evaluation of their results. The students are able to document their work according to the problem and results in written form, and present and discuss it in a suitable way. Despite the expertise needed for this performance, they will, furthermore, improve their methodological skills, team skills, and self-competence.

The Master's degree thesis has a processing time of 900 hours. This corresponds to about 22.5 40-hour weeks.
Master’s degree plan

This section shows the attribution of the courses to the four semesters of the master’s degree program in Optical Technologies.

### Master’s degree plan

<table>
<thead>
<tr>
<th>CP</th>
<th>1st term</th>
<th>2nd term</th>
<th>3rd term</th>
<th>4th term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Photonics Compulsory Module (5 CP)</td>
<td>Design and Simulation of optomechatronic Systems Compulsory Module (5 CP)</td>
<td>Student Project (10 CP)</td>
<td>Master Thesis (30 CP)</td>
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<tr>
<td>2</td>
<td>Optical Measurement Technology Compulsory Module (5 CP)</td>
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<tr>
<td>3</td>
<td>Laser Spectroscopy in Life Sciences Compulsory Module (5 CP)</td>
<td>Optional Modules (20 CP)</td>
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<td>16</td>
<td>Optional Modules (15 CP)</td>
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<tr>
<td>27</td>
<td>Master Lab Tutorial (5 CP)</td>
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<td>Project Pres. (1 CP)</td>
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<td>28</td>
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<tr>
<td>29</td>
<td></td>
<td></td>
<td>Studium Generale / Tutorials (4 CP)</td>
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<tr>
<td>30</td>
<td></td>
<td>Studium Generale / Tutorials (4 CP)</td>
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<tr>
<td>Σ</td>
<td>30</td>
<td>30</td>
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<td>30</td>
</tr>
</tbody>
</table>
Program Description

The Master of Science in Optical Technologies program is offered by the faculties of mechanical engineering and mathematics and physics and is coordinated by the Hannover Centre for Optical Technologies (HOT) at the Leibniz University Hannover. It provides students with scientific knowledge and research training in optics and photonics. The program prepares students for seeking employment in industry and academia in areas as diverse as optical technologies, product development, and commercialization.

The study program includes a balanced course including interdisciplinary scientific courses and research training in the field of optical technologies, which is widely used in industry, telecommunications and modern consumer devices, ranging from the tiny lasers in many disc drives to the thousands of kilometers of optical fibers carrying signals between continents.

Admissions to the program occur both in the winter and summer term of each year and students are expected to finish the degree within two years. Upon successful completion of the program, the student is awarded a Master of Science (M.Sc.) degree.

Personal Prerequisites

Great interest in optical problems is certainly necessary; however, very good skills in physics and engineering or related areas are indispensable. Also, a systematic description of optical phenomena is not possible without mathematical formulations. Therefore, mathematical skills are also recommended. Abstraction abilities, inter- and transdisciplinary thinking and the ability to think and work logical are also helpful.

Essentially, the program is intended for students with a Bachelor of Science (B.Sc.) degree in mechanical engineering or physics or related area.

Compulsory and Optional Modules

Postgraduate students must ensure that they have a total of 120 Credits.

Compulsory Modules

<table>
<thead>
<tr>
<th>Module</th>
<th>Responsible</th>
<th>Sem.</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical Measurement Technology</td>
<td>Rahlves</td>
<td>WS</td>
<td>5</td>
</tr>
<tr>
<td>Laser Spectroscopy in Life Sciences</td>
<td>Roth</td>
<td>WS</td>
<td>5</td>
</tr>
<tr>
<td>Design and Simulation of Optomechatronic Systems</td>
<td>Lachmayer</td>
<td>SS</td>
<td>5</td>
</tr>
<tr>
<td>Photonics</td>
<td>Chichkov</td>
<td>WS</td>
<td>5</td>
</tr>
</tbody>
</table>

Optional Modules

<p>| Module                                                          | Responsible  | Sem.  | Credits |
|                                                               |              |       |---------|
| Atomic Optics                                                  | Ospelkaus    | SS    | 4       |
| Atom Optics for Optical Technologies                          | Rasel        | SS    | 5       |
| Augmented Reality Apps for Mechatronics and Medical Engineering | Kahrss       | SS/WS | 4       |
| Automotive Lighting                                           | Wallaschek   | WS    | 5       |
| Biophotonics – Imaging Physics and Manipulation of Biological Cells | Heisterkamp | SS    | 4       |
| Computational Photonics                                      | Demircan     | SS    | 6       |
| Detection and Quantification of Optical Radiation             | Kovacev      | SS    | --      |
| Digital Image Processing                                     | Gigengack    | SS    | 5       |</p>
<table>
<thead>
<tr>
<th>Subject</th>
<th>Responsible</th>
<th>Sem.</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamentals of Laser Medicine and Biophotonics</td>
<td>Lubatschowski Krüger</td>
<td>WS</td>
<td>5</td>
</tr>
<tr>
<td>Laser Interferometry</td>
<td>Heinzel</td>
<td>WS/SS</td>
<td>3</td>
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<tr>
<td>Laser Material Processing</td>
<td>Overmeyer</td>
<td>SS</td>
<td>5</td>
</tr>
<tr>
<td>Laser Measurement Technology</td>
<td>Roth</td>
<td>SS</td>
<td>5</td>
</tr>
<tr>
<td>Nonlinear Optics</td>
<td>Demircan</td>
<td>SS</td>
<td>5</td>
</tr>
<tr>
<td>Optical 3D-Measurement</td>
<td>Wiggenhagen</td>
<td>SS</td>
<td>4</td>
</tr>
<tr>
<td>Optical Coatings and Layers</td>
<td>Ristau</td>
<td>WS</td>
<td>4+1</td>
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<tr>
<td>Photogrammetric Computer Vision</td>
<td>Heipke</td>
<td>WS</td>
<td>5</td>
</tr>
<tr>
<td>Production of Optoelectronic Systems</td>
<td>Overmeyer</td>
<td>WS</td>
<td>5</td>
</tr>
<tr>
<td>Proseminar Biophotonics</td>
<td>Roth</td>
<td>WS/SS</td>
<td>3</td>
</tr>
<tr>
<td>Proseminar Nonlinear Fiber Optics</td>
<td>Demircan</td>
<td>SS</td>
<td>3</td>
</tr>
<tr>
<td>Radar Remote Sensing</td>
<td>Motagh</td>
<td>SS</td>
<td>3</td>
</tr>
<tr>
<td>Remote Sensing I</td>
<td>Melsheimer</td>
<td>WS</td>
<td>4</td>
</tr>
<tr>
<td>Remote Sensing II</td>
<td>Melsheimer</td>
<td>SS</td>
<td>4</td>
</tr>
<tr>
<td>Seminar Numerical Optics</td>
<td>Roth</td>
<td>SS</td>
<td>3</td>
</tr>
<tr>
<td>Seminar Optics at Femto- and Attosecond Scales</td>
<td>Morgner, Kovacev</td>
<td>WS</td>
<td>3</td>
</tr>
<tr>
<td>Seminar Theory and practice of optical functional layers</td>
<td>Ristau</td>
<td>SS</td>
<td>3</td>
</tr>
<tr>
<td>Solid State Lasers</td>
<td>Weßels</td>
<td>SS</td>
<td>2</td>
</tr>
<tr>
<td>Ultrashort Laser Pulses</td>
<td>Babushkin</td>
<td>SS</td>
<td>2</td>
</tr>
<tr>
<td>XUV Laser Physics</td>
<td>Kovacev</td>
<td>WS</td>
<td>5</td>
</tr>
</tbody>
</table>

### Additional Mandatory Modules

For all students who require additional mandatory modules. There are two modules available which replace the mandatory lectures as follows:

<table>
<thead>
<tr>
<th>Module</th>
<th>Responsible</th>
<th>Sem.</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid State Lasers</td>
<td>Weßels</td>
<td>SS</td>
<td>/</td>
</tr>
<tr>
<td>Replaces the mandatory modules:</td>
<td></td>
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<tr>
<td>• Einführung in die Festkörperphysik</td>
<td></td>
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</tr>
<tr>
<td><strong>This module can only acknowledged once! Students who are affected have to attend an additional course to match their ECTS-goal!</strong></td>
<td></td>
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</tr>
<tr>
<td>Optics, atomic and quantum physics</td>
<td>Morgner</td>
<td>WS</td>
<td>/</td>
</tr>
<tr>
<td>Replaces the mandatory modules:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Optik, Atomphysik, Quantenphänomene</td>
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<tr>
<td>• Atom- und Molekülphysik</td>
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<tr>
<td>• Moleküle, Kerne, Teilchen, Festkörper</td>
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</tbody>
</table>
Course Descriptions

In this chapter, the descriptions of the individual courses (compulsory and elective) follow. For each course the course title as listed in the lecture list, the type of lecture, the course number, the responsible lecturer, the corresponding institute and a contact address in case of questions can be taken.

A short descriptive text is followed by the indication of study time as well as the ECTS credits to be awarded, which are to be evaluated as follows:

**Presence and Self-Study time**

The presence- or self-study time indicates how many hours the student has to invest in the course. The time the student actively participates in the lecture is considered to be the presence-time. The time it takes for the student to work up the content on his own or to work through the exercises is considered to be the self-study time.

**ECTS-CP**

The ECTS credit points are a measure of the processing time that students invest in a course. According to the stipulations of the Conference of Ministers of Education, one (1) ECTS-CP will be awarded per 25-30 hours of study time.

**Course Volume**

One semester week hour means 45 minutes of the course per week during the lecture period (around 14 to 15 weeks per semester)

- L: Lecture
- E: Exercise
- La: Laboratory
- S: Seminar

**Type of Examination**

Written or oral exams are administered by the teaching professor.
Recent experimental procedures to investigate the physics of ultracold gases, laser manipulation of single atoms and quantum engineering are discussed experimentally and theoretically. Students will gain insight in recent developments in the field of atomic physics.

Contents:
- Matter-light interaction
- Radiation pressure
- Atom- and ion traps
- Cooling by evaporation
- Bose-Einstein condensation
- Ultracold Fermi gases
- Experiments based on ultracold and degenerated gases
- Atoms in periodic optical gratings
- ATOMICS and modern atomic physics experiments

Prior knowledge
Atom and Molecular Physics, Quantumoptics

Recommended literature
R. Loudon, "The Quantum Theory of Light", OUP 1973
Van der Straaten

Additional Information
---

Presence studies time: -- Type of exam -- Course content L2/E1
Self-study: -- ECTS-CP: 4 Semester SS
Atom Optics for Optical Technologies

Title: Atom Optics for Optical Technologies
Type: Lecture
Number: 298164 (Lecture), 298173 (Exercise)
Lecturer: Dr. Dennis Schlippert, Prof. Dr. Ernst Rasel
Institute: Institut für Quantenoptik
www.iqo.uni.hannover.de
Email: schlippert@iqo.uni-hannover.de

Event description:
The aim of this lecture course is the introduction of engineering students to the basic principles of atom optics. As a foundation, the fundamental aspects and concepts of quantum mechanics, such as wave functions, Schrödinger equation and the principle of superposition are provided. Afterwards, fundamental and technological aspects and applications of matter wave interferometers are discussed and put into context with their optical analogons.

The exercise course aims at consolidating the understanding of the basic principles and provides theoretical exercises according to selected example applications and delivers intensified direct context to quantum optics laboratories.

Contents:
- Foundations of quantum mechanics
- Mathematical methods
- Wave functions & Schrödinger equation
- Principle of superposition
- Matter wave interferometry
- Fundamental aspects, atom-light interaction
- Technological aspects, e.g. in the context of noise in atom interferometers
- Applications

Prior knowledge
Basics of laser physics and laser technology, “Optik, Atomphysik und Quantenphänomene” (Exphy 3)

Recommended literature
Metcalf & van der Straten, Laser cooling and trapping, Springer-Verlag 2002

Additional Information
Recommended for second semester and higher (Master course)

<table>
<thead>
<tr>
<th>Presence studies time:</th>
<th>32h</th>
<th>Type of exam:</th>
<th>written</th>
<th>Course content:</th>
<th>L2/E1</th>
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</thead>
<tbody>
<tr>
<td>Self-study:</td>
<td>118h</td>
<td>ECTS-CP:</td>
<td>5</td>
<td>Semester:</td>
<td>SoSe</td>
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### Augmented Reality Apps for Mechatronics and Medical Technology

Augmented Reality Apps für Mechatronik und Medizintechnik

<table>
<thead>
<tr>
<th>Title:</th>
<th>Augmented Reality Apps für Mechatronik und Medizintechnik</th>
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<tr>
<td>Number:</td>
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<tr>
<td>Lecturer:</td>
<td>Dr.-Ing. Lüder A. Kahrs</td>
</tr>
<tr>
<td>Institute:</td>
<td>Institut für Mechatronische Systeme, <a href="http://www.imes.uni-hannover.de">www.imes.uni-hannover.de</a></td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:lueder.kahrs@imes.uni-hannover.de">lueder.kahrs@imes.uni-hannover.de</a></td>
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</tbody>
</table>

#### Event description:

The course comprises development of apps for mobile devices in the field of mechatronics and medical technology. The target operating system is Android. A special focus is the usage of display and camera for augmented reality scenarios. Image processing and visualization techniques are important side aspects. The students will get insights of the IDE Android Studio and the library Vuforia. Further topics of the course are visualization concepts, mixed reality, object recognition, navigation, etc.

#### Prior knowledge

Required knowledge: Programing under Java, C or C++

#### Recommended literature

Online tutorials for Android Programming, Vuforia bzw. ARToolKit und OpenCV

#### Additional Information

The course is limited to 10 teams of 2 students each.

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<th>Written/oral</th>
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<td>L2/E1</td>
<td>WS/SS</td>
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**Automotive Lighting**

Kraftfahrzeug - Lichttechnik

<table>
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<tbody>
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<tr>
<td>Number:</td>
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<tr>
<td>Lecturer:</td>
<td>Prof. Dr.-Ing. Jörg Wallaschek, Prof. Dr.-Ing Roland Lachmeyer</td>
</tr>
<tr>
<td>Institute:</td>
<td>Institut für Dynamik und Schwingungen, <a href="http://www.ids.uni-hannover.de">www.ids.uni-hannover.de</a></td>
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<tr>
<td>Email:</td>
<td><a href="mailto:wallaschek@ids.uni-hannover.de">wallaschek@ids.uni-hannover.de</a></td>
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**Event description:**

The course offers an introduction into automotive lighting technology and teaches the technological and physiological fundamentals which are necessary to understand and evaluate lighting systems. In addition to the required optical variables the state of the art and future trends of automotive lighting will be presented. Important technologies like for example new light sources and their application in automotive front and signal lights as well as in further optical systems will be considered. One main aspect of the lecture focusses on light-based driver assistance systems (e.g. glare free high beam, marking light) which are one core aspect of today’s technological development. Physiological and psychological basics like the structure of the human eye and the visual sense complete the course.

**Contents:**

- Basics of lighting
- Light sources, headlights, rear lights
- Mechanical and electronical components
- Light-based driving assistance systems
- Basics of human vision
- Structure of the human eye
- Photopic, mesopic and scotopic vision
- Disability and discomfort glare
- Environment sensor systems
- Image processing
- Active lighting systems

**Prior knowledge**

---

**Recommended literature**


**Additional Information**

The course consists of three parts: 1) a series of 6 introductive lectures as well as a practical training in light measurement technology, 2) preparation of lectures and the according presentation by the students themselves, 3) an excursion to a company or research facility in the field of vehicle lighting, e.g. Volkswagen AG in Wolfsburg, Hella or the L-LAB in Lippstadt.

<table>
<thead>
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<td>Semester</td>
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### Biophotonics – Imaging and Manipulation of Biological Cells

<table>
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<tr>
<th>Title:</th>
<th>Biophotonik – Bildgebung und Manipulation von biologischen Zellen</th>
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<tr>
<td>Number:</td>
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<tr>
<td>Lecturer:</td>
<td>Prof. Dr. Alexander Heisterkamp</td>
</tr>
<tr>
<td>Institute:</td>
<td>Laser Zentrum Hannover e.V. and Institut für Quantenoptik</td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:a.heisterkamp@lzh.de">a.heisterkamp@lzh.de</a></td>
</tr>
</tbody>
</table>

**Event description:**

Within the lecture “Biophotonics” laser technologies and optical methods will be introduced, which are applied within modern cell biology, regenerative medicine and the field of tissue engineering. Especially laser based imaging technologies, applied at the cellular level, will be covered, as well as tissue characterization and 3D volumetric imaging. This includes the fundamentals of microscopical imaging, different contrast mechanisms and optical clearing, as well as optical coherence tomography, and laser scanning microscopy and super resolution approaches. Furthermore, application within biotechnology, such as biochips, cell sorting and cell surgery and interaction with nanoparticles and nanostructures will be discussed.

The students will acquire knowledge within this interdisciplinary field of physics, engineering, life science and medicine. The covered areas will be exemplarily discussed using examples of current research themes investigated at joint projects with the MHH and the excellence cluster REBIRTH (From Regenerative Biology to Reconstructive Therapy).

Aside from teaching the fundamentals and facts of biophotonics, the lecture introduces the students to the search and understanding of original research articles. With each topic covered within the lecture, recent articles from research journals will be discussed in monthly tutorials. In one of these tutorials the article search using internet search engines will be covered (at the RRZN). The other tutorials will take place at the seminar room of the IQ, in which the relevant article will be discussed.

**Prior knowledge**

Basic knowledge in coherent optics  
Possibly Fundamentals of Lasers in Medicine and Biomedical Optics (WS), Laserphysics

**Recommended literature**

- Basic Methods in Microscopy, Spector, Goldman  
- Introduction to Biophotonics, P.N. Prasad  
- Laser Manipulation of Cells and Tissues, M.W. Berns, K. O. Greulich  
- Atala, Lanza, Thomson, Nerem: Principles of Regenerative Medicine  

**Additional Information**

Limited places in tutorial (30) (PC workstations at the RRZN)

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Computational Photonics

Title: Computational Photonics
Type: Lecture
Number: 13149
Lecturer: Ihar Babushkin, Ayhan Demircan, Oliver Melchert, Uwe Morgner
Institute: Institut für Quantenoptik, www.iqo.uni-hannover.de
Email: demircan@iqo.uni-hannover.de

Event description:

The lecture is organized in two parallel-running tracks: Photonics Fundamentals, and Numerical Methods. The course has a practical exercise component providing the student with basic computer simulation experience.

Inhalt:

- Light-matter interaction (Chromatic and geometric dispersion, second- and third-order susceptibility, Raman scattering, supercontinuum generation, multiphoton und tunneling ionization, low-order harmonic radiation)
- Laserdynamics (Mode-locking, Rate equation, Q-switching)
- Light transport in turbid media
- Photoacoustics
- Matrix optics
- Pulse propagation equations
- Atoms in strong optical fields (Schrödinger equation for atoms, Higher-Harmonic generation, Brunel/THz radiation, attosecond optics)
- Computer modeling methods in electromagnetics (Time-domain solvers, frequency domain methods, finite element methods)
- Monte Carlo method
- Optimization algorithms
- Spectral and Pseudospectral methods
- Runge-Kutta and operator splitting approach
- Parallel computing (openMP, openMPI)

Prior knowledge

--

Recommended literature

Obayya, „Computational Photonics“, Wiley

Additional Information

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**Design and Simulation of Optomechatronic Systems**

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</tr>
<tr>
<td>Institute:</td>
<td>Institut für Produktentwicklung und Gerätebau, <a href="http://www.ipeg.uni-hannover.de">www.ipeg.uni-hannover.de</a></td>
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<td>Email:</td>
<td><a href="mailto:wolf@ipeg.uni-hannover.de">wolf@ipeg.uni-hannover.de</a></td>
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</table>

**Event description:**

The course Design of Optical Systems provides knowledge about the specific design and manufacturing process of optical devices. The path of the light is considered from various light sources over different light shaping and modifying optical elements to the perception by the human eye. The course focuses on the methodological construction process, product development and optimization. Practical examples arise from vehicle lighting and connections to manufacturing technology and metrology. Exercises with optical simulation software complete the event.

**Prior knowledge**

Construction basics, fundamental optics

**Recommended literature**

Lecture script

**Additional Information**

Exercises, e.g. with optics simulation software

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<td>Semester</td>
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</table>
Detection and Quantification of Optical Radiation

Title: Detection and Quantification of Optical Radiation
Type: Lecture + Lab
Number: 12532 (Lecture), 12413 (Lab)
Lecturer: Prof. Milutin Kovacev
Institute: Institut für Quantenoptik
Email: 

Event Description:

Contents:
- Radiometry
- Photometry
- Optical devices for light measurement
- Laser safety

Example projects:
  Build up of a Power-Meter, Spectroscopy, Radiometry measurements of hazardous light sources, Light pulse detection, Coherent diffraction imaging, UV microscopy

Prior knowledge
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Recommended Literature
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Additional Information
A new teaching concept will give the students the possibility to build their knowledge from hands-on projects. This concept aims to provide training for students in basic research skills like presenting, evaluating and analysing experimental research.

Presence studies
time: -- Type of exam: -- Course content ---
Self-Study -- ECTS-CP: -- Semester SS
**Digital Image Processing**

Digitale Bildverarbeitung

**Event description**

The students are familiar with two-dimensional discrete systems, scanning, the basics of visual perception, discrete geometry, image restoration, image processing and image analysis.

**Contents:**

- Fundamentals
- Linear System Theory
- Image Description
- Discrete geometry
- Color and texture
- Transformations
- Image Editing
- Image restoration
- Image Coding
- Image analysis

**Prior knowledge**

Engineering mathematics, digital signal processing (recommended)

**Recommended literature**

Jähne, Bernd: Digitale Bildverarbeitung, Springer Verlag, 1997
Haberäcker, Peter: Praxis der Digitalen Bildverarbeitung und Mustererkennung, Carl Hanser Verlag, 1995
Abmayr, Wolfgang: Einführung in die digitale Bildverarbeitung, Teubner Verlag, 1994
Pinz, Axel: Bildverstehen, Springer Verlag, 1994
Ohm, Jens-Rainer: Digitale Bildcodierung, Springer Verlag, 1995
Girod, Rabenstein, Stenger: Einführung in die Systemtheorie, Teubner Verlag, 1997

**Additional information**

Short testat

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</table>
Fundamentals of Laser Medicine and Biophotonics
Grundlagen der Lasermedizin und Biophotonik

Title: Grundlagen der Lasermedizin und Biophotonik
Type: Lecture
Number: 12130
Lecturer: apl. Prof. Dr. Holger Lubaschowski, Prof. Dr. Alexander Heisterkamp
Institute: Institut für Quantenoptik, www.iqo.uni-hannover.de
Email: a.krueger@lzh.de

Event description:
The lecture explains laser medicine with basics from biophotonics. The laser principle, types of medical lasers and their effects on biological tissue are presented. As current clinical application, laser surgery of the eye based on ultrashort pulse lasers is discussed.
After a fundamental introduction to tissue optics with its various absorption and scattering processes, imaging techniques such as optical coherence tomography (OCT) and two-photon microscopy will be explained. After the lecture, an excursion with laboratory and company visit is offered.

Contents:
- Laser systems for the application in medicine and biology
- Beam guiding systems and optical medical devices
- Optical properties of tissues
- Thermal properties of tissues
- Photochemical interaction
- Vaporization/coagulation
- Photoablation, optoacoustics
- Photodisruption, nonlinear optics
- Applications in ophthalmology, refractive surgery
- Laser-based diagnostics, optical biopsy
- Optical coherence tomography, theragnostics
- Clinical examples

Prior knowledge
Coherent Optics, Photonics or Nonlinear Optics

Recommended literature
Eichler, Seiler: "Lasertechnik in der Medizin"; Springer-Verlag
Berlien, Müller: "Angewandte Lasermedizin"; Bd. 1,2, eco med Verlag
Berlien, Müller: "Applied Laser Medicine"; Springer-Verlag

Additional Information
Examination: The students present current publications in the field within the scope of a block seminar. This will be followed by an examination on the publication and on lecture contents.
Study achievement: Participation in lecture and block seminar.

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<td>Semester</td>
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</table>

19
Laser Interferometry

Laserinterferometrie

Title: Laserinterferometrie
Type: Lecture
Number: 12412
Lecturer: apl. Prof. Gerhard Heinzel
Institute: Institut für Gravitationsphysik, www.aei.mpg.de
Email: gerhard.heinzel@aei.mpg.de

Event description:

Students acquire knowledge of modern laser interferometry. The emphasis of the lecture is laid in laser interferometers for gravitational wave detection such as well as in laser interferometry on satellites (LISA Pathfinder, GRACE Follow-On, LISA).

Contents:
- Michelson-, Mach-Zehnder- und Fabry-Perot interferometer
- Thermal noise
- Mechanical quality of hanging lenses
- Applications for measurement of Gravitational waves and the gravity field of the earth
- Description Gaussian rays and higher methods
- Transformation of Gaussian rays
- Selection procedures: internal, external and Schnuppmodulation; Pound-Drever Hall procedure
- Polarization
- Transfer function and control loops

Applications: GEO600, LISA, GRACE Follow-On

Prior knowledge

Coherent Optics, nonlinear Optics

Recommended literature


Additional Information

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<th>Presence studies time:</th>
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## Event description:
The course covers the spectrum of laser technology in the production as well as the potential of laser technology for future applications. We explain the scientific and technical basic knowledge, which is used in the laser systems as well as in the interaction of the beam with different materials. On the basis of applications in subject areas such as micromachining, the required physical conditions for laser processing such as wavelength, fluence, pulse peak power, are worked out and described in connection with the specific process, handling and control technology. The purpose is to develop an understanding of the basics and the current demands for laser technology to provide an access for the participants into laser technology in industry.

## Prior knowledge
Basic optics, Light sources II

## Recommended literature
Recommendation made in the lecture; lecture script

## Additional Information
Lectures and exercises seminars in the rooms of Laser Zentrum Hannover e.V. (Laboratory/test areas) Dedicated English and german taught lectures and exercises.

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Event description:
The aim of this lecture course is the introduction to the basic principles and methods of state-of-the-art optical measurement technology based on laser sources. An overview of the broad spectrum of laser sources, measurement techniques, and typical practical applications for various optical measurement, monitoring, and sensing situations in research and development will be provided. The exercise course aims at consolidating the understanding of the basic principles and provides theoretical exercises according to selected example applications and practical laboratory training.

Content:
- Basic physics
- Optical elements/detection techniques
- Lasers for measurement applications
- Laser triangulation and interferometry
- Distance and velocity measurement
- Laser spectrometry
- Holographic measurement techniques
- Ultra-short laser pulse measurement techniques
- Application in measurement, monitoring, and sensing

Prior knowledge
Fundamentals of measurement technology, Basics of laser physics and laser technology

Recommended literature

Additional Information
Recommended for second semester and higher (Master course)
**Laser Spectroscopy in Life Science**

Laserspektroskopie in Life Science

<table>
<thead>
<tr>
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<tr>
<td>Number:</td>
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<tr>
<td>Lecturer:</td>
<td>Prof. Dr. Bernhard Roth</td>
</tr>
<tr>
<td>Institute:</td>
<td>Hanover Centre for Optical Technologies, HOT, <a href="http://www.hot.uni-hannover.de">www.hot.uni-hannover.de</a></td>
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</table>

**Event description:**

The aim of this lecture course is the introduction to the fundamentals and methods in laser spectroscopy for application in the life sciences. Apart from the basic principles of laser spectroscopic techniques and methods applied in various up-to-date areas of fundamental research also practical applications in the life sciences such as biology, chemistry, and medicine, will be taught. The students will also gain insight into modern measurement devices and methods which are broadly employed. The exercise course aims at consolidating the understanding of the basic principles given as well as at their application for practical examples.

**Prior knowledge**

Mandatory: Basic physics, optics and laser physics, laser applications
Recommended: optical components and measurement principles, spectroscopy, laser interferometry, (ultra) short pulse laser

**Recommended literature**

Jürgen Eichler, Hans Joachim Eichler: Laser - Bauformen Strahlführung Anwendungen (Springer), 2010
Thomas Engel: Quantum Chemistry and Spectroscopy (Pearson), 2013

**Additional Information**

Recommended for second semester and higher (Master course)

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Non-linear Optics

Title: Nichtlineare Optik
Type: Lecture
Number: 13080
Lecturer: Prof. Dr. Detlev Ristau
Institute: Institut für Quantenoptik, www.iqo.uni-hannover.de
Email: faber@iqo.uni-hannover.de

Event description:
- Nonlinear optical susceptibility
- Crystal optics, tensor optics
- Wave equation with nonlinear source terms
- Frequency doubling, sum-, difference-frequency generation
- Optical parametric amplifier, oscillator
- Phase-matching schemes, quasi phase-matching
- Electro-optical effect
- Electro-acoustic modulator
- Frequency tripling, Kerr-effect, self-phase modulation, self-focusing
- Raman-, Brillouin-scattering, four wave mixing
- Nonlinear propagation, solitons

Prior knowledge
Atom and molecular physics

Recommended literature
- Dmitriev, *Handbook of nonlinear crystals*, Springer

Original literature

Additional Information

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## Optical Coatings and Layers

**Title:** Optische Schichten  
**Type:** Lecture  
**Number:** 12140  
**Lecturer:** Prof. Dr. Detlev Ristau  
**Institute:** Institut für Quantenoptik, http://www.iqo.uni-hannover.de/  
**Email:** d.ristau@lzh.de

### Event description:

Optical coatings can be considered as essential key-components in modern Photonics. For example, present laser sources, optical systems and products or even a major part of fundamental research could never be realized without optical coatings. In the course the fundamentals of coating design, production and characterization of functional layer systems will be presented.

Recent research areas of optical coating technology, especially in the fields of high precision industrial production and the optimization of coating systems for high power lasers will be introduced and discussed. The course offers a large variety of practical information on optical coatings, which may be of value for engineers and physicists heading towards a career in photonics.

### Contents:

- General basis (applications, impact, and functional principle of optical coatings, state of the art in coatings for laser technology)
- Theoretical fundamentals (compilation of formulae and consideration of fundamental phenomena, calculation of single layers and layer systems)
- Production of optical components (substrates, coating materials and techniques, control of coating processes)
- Optics characterization (measurement of optical transfer properties, optical losses: Total Scattering and absorption, laser induced damage thresholds of laser components, non-optical properties)

### Prior knowledge

Fundamentals of optics and physics

### Recommended literature

Will be announced during the course, for an introduction:  

### Additional Information

Three exercise sheets for homework, solution of exercises discussed during the course, major course assessment alternatively by colloquium, oral examination, or by written test  
Compulsory internship (1 CP) with a duration of approx. 16 hours. The internship can only be completed after successful completion of the examination. The internship includes a general introduction to technological aspects of optical thin-film production taking about 4 hours and a technical part. The technical part will usually be directed to the production of an exemplary layer system and its analysis. The internship can be completed in three short blocks of 4 hours each at the LZH.

<table>
<thead>
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25
**Optical 3D-Measurement**

Optische 3D Messtechnik

<table>
<thead>
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<tr>
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<td>Dr.-Ing. Manfred Wiggenhagen</td>
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<tr>
<td>Institute:</td>
<td>Institut für Photogrammetrie und Geoinformation, <a href="http://www.ipi.uni-hannover.de">www.ipi.uni-hannover.de</a></td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:wiggenhagen@ipi.uni-hannover.de">wiggenhagen@ipi.uni-hannover.de</a></td>
</tr>
</tbody>
</table>

**Event description:**

As part of this lecture, students acquire knowledge in optical 3D metrology using digital cameras. The focus is on the stereoscopic recording and evaluation in indoor and outdoor projects with the aim of being able to calculate both highly accurate and statistically reliable three-dimensional point coordinates from multiple images and adapted estimation methods and to generate surfaces. The students get to know the advantages and disadvantages of different sensors (commonly available cameras, special measuring cameras, systems with active lighting) and learn to calibrate them accordingly. Current practical applications supplement the theoretical material.

**Prior knowledge**

Successful participation in the lecture "Photogrammetric Computer Vision"

**Recommended literature**


**Additional Information**

Exercises take place during the lecture using modern imaging sensors

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Optical Measurement Technology
Optische Messtechnik

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<tr>
<td>Number:</td>
<td>32996</td>
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<tr>
<td>Lecturer:</td>
<td>Prof. Dr.-Ing. Eduard Reithmeier, Dr.-Ing. habil. Maik Rahlves</td>
</tr>
<tr>
<td>Institute:</td>
<td>Hannover Centre for Optical Technologies, HOT, <a href="http://www.hot.uni-hannover.de">www.hot.uni-hannover.de</a></td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:maik.rahlves@hot.uni-hannover.de">maik.rahlves@hot.uni-hannover.de</a></td>
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</table>

Event description:
The lecture gives an overview on theory, methods and devices in optical metrology. At the beginning, fundamentals of optics and photonics such as ray and wave optics are revised, which are essential for the understanding of concepts in optical metrology. Focusing on metrology in research and industrial applications, the lecture covers optical methods for measurement of topography, distance, and deformation as well as fiber optical sensors, which include concepts such as interferometry, holography and confocal microscopy. In addition, semi-optical methods such as atomic force microscopy and near field microscopy are addressed and compared to non-optical methods, e.g., scanning electron microscopy. To gain an in-depth understanding of the concepts involved in optical metrology, all devices and optical setups are explained in detail including light sources, cameras, and optical elements.

Prior knowledge
Fundamentals of Measurement

Recommended literature
Born, Wolf: Principles of Optics;
Hecht: Optics;
Saleh, Teich: Fundamentals of Photonics;
Lauterborn, Kurz: Coherent Optics;
Goodman: Introduction to Fourier Optics;
Hugenschmidt: Lasermesstechnik;
Demtröder: Experimentalphysik

Additional Information

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Type of exam: oral
ECTS-CP: 5
Course content: L2/E1
Semester: WS
### Optics, atomic and quantum physics (conditional module)

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<tr>
<td>Number:</td>
<td>12454</td>
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<tr>
<td>Lecturer:</td>
<td>Prof. Dr. Alexander Heisterkamp</td>
</tr>
<tr>
<td>Institute:</td>
<td>Institut für Quantenoptik, <a href="http://www.iqo.uni-hannover.de">www.iqo.uni-hannover.de</a></td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:faber@iqo.uni-hannover.de">faber@iqo.uni-hannover.de</a></td>
</tr>
</tbody>
</table>

**Event description:**

**Topics:**
- Geometrical optics
- Wavelike properties of light: Interference, refraction, polarization, birefringence
- Optics, optical instruments
- Matter waves, wave-particle dualism
- Composition of atoms
- Energy states, angular momentum, magnetic moment
- Pauli principle
- Spectroscopy, spontaneous and stimulated emission

**Prior knowledge**
- 

**Recommended literature**
- Born, Wolf: Principles of Optics
- Saleh, Teich: Fundamentals of Photonics;
- Lauterborn, Kurz: Coherent Optics

**Additional Information**

Additional module for students who are imposed with some or all of the following German lectures:
- Optik, Atomphysik, Quantenphänomene
- Moleküle, Kerne, Teilchen, Festkörper
- Atom- und Molekülphysik

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</table>

| Semester | WS |
**Photogrammetric Computer Vision**

| Title: | Photogrammetric Computer Vision |
| Type: | Lecture |
| Number: | 28225 |
| Lecturer: | Prof. Dr. Christian Heipke |
| Institute: | Institut für Photogrammetrie und GeoInformation, [http://www.ipi.uni-hannover.de/](http://www.ipi.uni-hannover.de/) |
| Email: | reich@ipi.uni-hannover.de |

**Event description:**

After attending this module, the students have a good overview and detailed knowledge of some exemplary methods of 3D reconstruction from images and image sequences (structure from motion, sfm). They understand the geometric transformations between image and object space, the usual procedures for pose estimation of moving sensors and basics of signal theory as applied to image matching. Students can thus evaluate pros and cons of sfm.

In the lab part, carried out in small groups, image sequences are captured using flying robots; these image sequences are being exploited using available software. In this way the students come to gain practical experience of digital image capture and geometric 3D reconstruction and can evaluate the obtained results.

**Prior knowledge**

- 

**Recommended literature**


[http://www.cs.cmu.edu/~cil/vision.html](http://www.cs.cmu.edu/~cil/vision.html)

**Additional Information**

Lab work, oral exam

| Presence studies time: | 32h | Type of exam: | oral |
| Self-study: | 118h | ECTS-CP: | 5 |
| Course content | | | L2/E2 |
| Semester | | | WS |
Photonics
Photonik

Title: Photonik
Type: Lecture
Number: 12457
Lecturer: Prof. Dr. Boris Chichkov, Dr. Ulf Hinze
Institute: Institut für Quantenoptik, www.iqo.uni-hannover.de
Email: www.iqo.uni-hannover.de

Event description:
The students gain special knowledge in nonlinear and integrated optics, and they can apply the corresponding mathematical methods. A special topic of photonics can be selected and deepened independently by the student. The topic shall be presented in the frame of a seminar with a subsequent discussion. Besides their technical competence, the students develop their methods in literature research, implementation of technical and scientific knowledge, as well as their presentation techniques together with their ability to lead scientific discussions.

Contents:
- Waves in Media and at Boundaries
- Dielectric Waveguides (planar, fiber), Integrated Waveguides
- Waveguide Modes
- Nonlinear Fiber Optics
- Fiber optic components (Circulators, AWG, Fiber-Bragg-Gratings, Modulators), Optical Communication (WDM/TDM)
- Fiberlaser
- Laserdiodes, Photodetectors
- Plasmonics, Photonic Crystals
- Transformation Optics

Prior knowledge
Basic knowledge in coherent optics, Nonlinear Optics Lecture

Recommended literature
Saleh, Teich: Photonics, Wiley;
Boyd: Nonlinear Optics, Academic Press

Additional Information
Final mark: 80% oral exam, 20% seminar.

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30
**Production of Optoelectronic Systems**

<table>
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<tr>
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<tr>
<td>Lecturer:</td>
<td>Prof. Dr.-Ing. Ludger Overmeyer</td>
</tr>
<tr>
<td>Institute:</td>
<td>Institut für Transport- und Automatisierungstechnik, <a href="http://www.ita.uni-hannover.de">www.ita.uni-hannover.de</a></td>
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<tr>
<td>Email:</td>
<td><a href="mailto:Ludger.overmeyer@ita.uni-hannover.de">Ludger.overmeyer@ita.uni-hannover.de</a></td>
</tr>
</tbody>
</table>

**Event description:**

This module gives basic knowledge about processes and devices that are used in production of semiconductor packages and microsystems. The main focus is on the back-end-process that means the process thins wafer dicing. After successful examination in this module the students are able to:

- correctly use the terms optoelectronic system, wafer production, front end and back end and to give an overview of production processes of semiconductor packages
- explain the production processes beginning from crude material sand and to have an idea about process relevant parameters
- visualize different packaging techniques and explain the corresponding basics of physics
- choose and classify different package types for an application

**Contents:**

- Wafer production
- Mechanical Wafer treatment
- Mechanical connection methods (micro bonding, soldering, eutectic bonding)
- Electrical connection methods (wire bonding, flip chip bonding, TAB)
- Package types for semiconductors
- Testing and marking of packages
- Design and production of printed circuit boards
- Printed circuit board assembly and soldering techniques

**Prior knowledge**

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**Recommended literature**


Lecture script

**Additional Information**

Distinct English- and German taught lectures available

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<tr>
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Proseminar Biophotonics

Title: Proseminar Biophotonik
Type: Proseminar
Number: 12137e
Lecturer: Dr. Merve Wollweber, Dr.-Ing. habil. Maik Rahlves, Prof. Dr. Bernhard Roth, Prof. Dr. Uwe Morgner
Institute: Hannoversches Zentrum für Optische Technologien
Email: bernhard.roth@hot.uni-hannover.de
merve.wollweber@hot.uni-hannover.de
maik.rahlves@hot.uni-hannover.de

Event description:
The focus of the proseminar lies on the applications of optical technologies, methods and processes in the life sciences. The students acquire knowledge on both basic concepts and their implementation into real applications. Typical fields of application are optical microscopy and imaging for medical diagnosis or precision laser spectroscopy for the investigation of the functionality of biomolecules and molecular analytics. Furthermore, emphasis will be placed on modern optical technology for lab-on-chip applications and integrated laser methods for medical screening, among others.

Prior knowledge
- Basics of physics
- Optical elements / Measurement techniques
- Physical foundations of optics and laser technology
- Basic knowledge in laser applications

Additional Information
Graded performance: oral examination and presentation slides
Type of examination: oral (marked or unmarked, as required)

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Proseminar Nonlinear Fiber Optics
Proseminar Nichtlinear Faseroptik: Superkontinuumserzeugung, Monsterwellen und Schwarze Löcher

Title: Proseminar Nichtlinear Faseroptik: Superkontinuumserzeugung, Monsterwellen und Schwarze Löcher
Type: Proseminar
Number: 12137f
Dozent: PD Dr. Ayhan Demircan, Dr. Ihar Babushkin, Prof. Dr. Uwe Morgner
Institute: Institut für Quantenoptik
Email:

Event description:
Fiber-optical analogies to extremal phenomena from various fields of physics.

Prior knowledge
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Recommended literature
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Additional Information
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</table>
Radar Remote Sensing

Title: Radar Remote Sensing
Type: Lecture
Number: 28323
Lecturer: Prof. Dr. Madhi Motagh
Institute: Institut für Photogrammetrie und GeoInformation
Email:

Event description:
This course is intended to provide an introduction to the technique of Interferometry Synthetic Aperture Radar (InSAR) and its application for monitoring aspects of Earth’s surface including its topography and deformation. With the increasing availability of SAR systems it is becoming more crucial and important than ever to learn about these systems and to better understand what can be gained from SAR data for various types of natural disasters and engineering applications. The course covers mainly the underlying principle of InSAR measurement technique and time-series approaches of Permanent Scatterer (PS) and Small Baseline Subset (SBAS). The module will be accompanied by lab exercises that provide hands-on experience with classical processing techniques. At the end of the course the students will acquire knowledge and understanding of the fundamental concepts underlying radar remote sensing and will gain the ability to implement processing techniques to extract information from radar data. The lecture is complemented by reading and discussion of textbooks and journal papers, and a 1-day excursion to GeoForschungsZentrum (GFZ) Potsdam towards the end of the semester.

Content:
- Introduction to two-dimensional radar imaging and Synthetic Aperture Radar (SAR)
- Image resolution and SAR geometric distortions
- SAR interferometry to measure Earth’s surface topography and deformation
- Airborne and space-borne SAR sensor systems
- How to access SAR data?
- Fundamental equation of Interferometry: Height ambiguity, sensitivity analysis, selection of baseline, critical baseline
- Typical processing chain: 2 and 3 pass Interferometry
- Application of radar remote sensing in geodesy, geophysics and environmental sciences
- Interferometric phase quality: Coherence
- Error sources: Residual topography; atmospheric error, phase unwrapping, decorrelation
- Time-series methods: Permanent/Persistent Scattered Interferometry (PSI) and Small Baseline Subset (SBAS)
- Latest development in SAR systems
- Lab: Interferometry exercise using public domain software DORIS

Prior knowledge:
Some familiarity with a Linux operating system is beneficial for lab exercises

Recommended literature:

Additional Information:

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Remote Sensing I

Event description

The students are learning the basics of remote sensing with emphasis on satellite meteorology, i.e. the measurement of meteorological parameters with satellites. Apart from boosting expert knowledge, the theoretical exercises also train communication skills and methodological competence.

Contents:
- Basics: Satellite orbits, electromagnetic radiation and radiative transfer
- Remote sensing with satellite instruments
- Deduction of temperature, clouds, trace gases, rainfall with remote sensing instruments of satellites
- Overview over current operative meteorological satellites and satellite instruments

Prior knowledge

Mandatory: Radiation I
Recommended: Radiation II

Recommended literature


Additional information

Presence studies time: 45h
Type of exam: oral
Course cont. L2/E1
Self-study: 75h
ECTS-CP 4
Semester WS
Remote Sensing II
Fernerkundung II

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<td>Dr. Christian Melsheimer</td>
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<td>Email</td>
<td><a href="mailto:melsheimer@uni-bremen.de">melsheimer@uni-bremen.de</a></td>
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</table>

Event description
The students are learning the basics of remote sensing of the land masses, the oceans and the atmosphere. Apart from boosting expert knowledge, the theoretical exercises also train communication skills and methodological competence.

Contents:
- Basics: Electromagnetic radiation, generation and measurement of radiation, radiative transfer
- Retrieval-methods, inverse methods
- Remote sensing (active and passive) of the land masses with visible light, infrared and microwaves
- Remote sensing (active and passive) of the oceans with visible light, infrared and microwaves
- Remote sensing (active and passive) of the atmosphere with visible light, infrared and microwaves, atmospheric probing
- Overview over important satellites and satellite instruments, current and historical

Prior knowledge
Mandatory: Remote Sensing I, Radiation I
Recommended: Radiation II

Recommended literature

Additional information
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### Seminar Numerical Optics

**Title:** Seminar Numerische Optik  
**Type:** Seminar  
**Number:** 12076  
**Lecturer:** Prof. Dr. Bernhard Roth, PD Dr. Ayhan Demircan, Prof. Dr. Uwe Morgner  
**Institute:** Institut für Quantenoptik  

**Event description:**  
Seminar covering selected topics for the calculation of light distributions in optical media.

**Contents:**  
- Spectral- and pseudospectral methods  
- Runge-Kutta- and Split-Step-Integration  
- Fast-Fourier Transform (FFT)  
- Monte Carlo (MC) simulation  
- Finite Difference Time Domain (FDTD)  
- Finite Element Methods  
- Ray Tracing  
- Beam-propagation methods (BPM)  
- Parallelization using MPI

**Prior knowledge**

**Recommended literature**

**Additional Information**

<table>
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ECTS-CP: 3, Semester SS
# Seminar Optics at Femto- and Attoscond Scales

Seminar Optik auf Femto- und Attosekunden Zeitskalen

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## Event description:

### Contents:

- High power femtosecond laser systems
- Interaction of matter with strong fields
- Filamentation / plasma channels
- The absolute carrier phase
- Quantum Interference Metrology / Mode Combs
- Relativistic optics / Laser particle acceleration
- Generation and detection of high harmonics
- Generation and detection of attosecond pulses
- Atomic photography
- The Free Electron Laser

## Prior knowledge

## Recommended literature

## Additional Information

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Seminar Theory and practice of optical functional layers

Seminar Theorie und Praxis optischer Funktionsschichten

<table>
<thead>
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<th>Title:</th>
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<tr>
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<td>Dr. Holger Badorreck, Dr. Marco Jupé, Prof. Dr. Detlev Ristau</td>
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<tr>
<td>Email:</td>
<td><a href="mailto:d.ristau@lzh.de">d.ristau@lzh.de</a></td>
</tr>
</tbody>
</table>

Event description

The major objective of the seminar is to acquire advanced skills concerning the characterization, calculation, and simulation of optical functional layers. After an introduction by the lecturers, defined tasks shall be studied in small groups (up to 3 persons, also of varying composition, all groups work in parallel on one issue, also for several days according to the specific task). The results obtained by the groups for the tasks will be briefly presented in a synopsis and jointly evaluated. The corresponding tasks include practical as well as theoretical aspects, however calculations and simulations will be in the foreground of the studies. The necessary equipment will be available at the Laser Zentrum Hannover. Work on own computers will be also possible and supported by granting the necessary software packages (licenses with limited usage time). The following tasks can be considered as a preliminary selection addressed by the seminar:

- theoretical foundations: thin-film technology
- introduction to the thin film software
- internship: (preparation and characterization of a single-layer)
- determination of optical parameters by means of the “Spektrum Software”
- anti-reflective coatings and highly reflective mirror calculated with thin film software
- complex systems: broad band mirrors and broadband anti-reflective coatings
- complex systems: Mirrors with defined phase gradients and/or Rugate structures
- considerations on layer simulation
- atomistic simulation: kMC, MD, structure formation
- atomistic simulation: structure analysis
- non-linear excitation and laser damage

Prior knowledge

Lecture “Optical coatings”

Recommended literature

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Additional information

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<table>
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<td>ECTS-CP</td>
<td>3</td>
<td>Semester</td>
<td>SS</td>
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**Event description:**
Within this lecture the fundamentals needed for the understanding of modern solid state lasers will be developed. In particular, the optical properties and typical parameters of different solid state laser designs will be developed. Furthermore, the application potential of the various solid laser designs will be treated.

**Contents:**
- Solid state laser media
- optical resonators
- laser modes of operation
- diode pumped solid state lasers
- laser designs: fiber, rod, disc; tunable lasers
- single-frequency lasers
- ultrashort-pulse lasers
- frequency conversion

**Prior knowledge**
Basic knowledge in physics and coherent optics

**Recommended literature**
W. Koechner, Solid-State Laser Engineering
A. E. Siegman, Lasers; O. Svelto, Principles of Lasers.

**Additional Information**
This course is equivalent to the german taught module “Fundamentals and Configuration of Laser Beam Sources”. Only one of these modules may be credited for the master course, respectively.

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<th>Presence studies time:</th>
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</table>
Ultrashort Laser Pulses

Title: Ultrakurze Laserpulse
Type: Lecture
Number: 13082
Lecturer: Prof. Dr. Uwe Morgner, Dr. Ihar Babushkin
Institute: Institut für Quantenoptik, www.iqo.uni-hannover.de
Email: babushkin@iqo.uni-hannover.de

Event description:

Contents:
- General basics of the linear and nonlinear interaction of light and matter.
- Nonlinear propagation of short optical pulses.
- Dynamics of lasers, mode-locking in lasers.
- Types of contemporary short pulse lasers.
- Applications of ultrashort pulses in physics, chemistry and biology.
- High energy laser systems.
- Generation of high harmonics and attosecond pulses.
- Relativistic optics.

Prior knowledge
Basic knowledge in physics and coherent optics

Recommended literature

Additional Information
---

Presence studies time: 24h  Type of exam: oral  Course content L2
Self-study: 34h  ECTS-CP: 2  Semester SS
XUV Laser Physics

XUV-Laserphysik

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<tr>
<td>Lecturer:</td>
<td>Prof. Dr. Milutin Kovacev</td>
</tr>
<tr>
<td>Institute:</td>
<td>Institut für Quantenoptik, <a href="http://www.iqo.uni-hannover.de">www.iqo.uni-hannover.de</a></td>
</tr>
<tr>
<td>Email:</td>
<td><a href="mailto:kovacev@iqo.uni-hannover.de">kovacev@iqo.uni-hannover.de</a></td>
</tr>
</tbody>
</table>

Event description:

- Introduction to coherent sources of XUV radiation
- XUV optics, detection
- XUV applications in atomic, molecular and solid-state physics

A new teaching concept will give the students the possibility to build their knowledge from hands-on projects.

Projects:

- High-power femtosecond laser systems
- Interaction of matter with strong fields
- Filamentation / plasma channels
- Absolute carrier phase
- Quantum Interference Metrology / Mode Combs
- Relativistic optics / laser particle acceleration
- Generation and detection of high harmonics
- Generation and detection of attosecond pulses
- Atomic photography
- Free-electron lasers

Prior knowledge

Basic knowledge in physics and coherent optics

Recommended literature

P. Jaegle, Coherent Sources of XUV Radiation

Additional Information

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<th>Presence time:</th>
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<td>Semester</td>
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ECTS-CP: 5
Facilities of the Faculty of Mechanical Engineering

Student Counselling
Jonas Kanngießer
Hannover Centre for Optical Technologies, Nienburger Straße 17, 30167 Hannover
Tel.: +49 (0)511 762-17943
E-Mail: lehre@hot.uni-hannover.de
Office hours: by appointment

Student association of the faculty of mechanical engineering
Student representatives
Otto-klüsener-Haus
Im Moore 11 B
30167 Hannover
E-Mail: fsr@fsr-mb.uni-hannover.de
Internet: www.maschinenbau.uni-hannover.de

AG Study information
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Michael Köhrmann
Phil Demter
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E-Mail: agstud@maschinenbau.uni-hannover.de
https://www.maschinenbau.uni-hannover.de/ag-studieninformation.html
Office hours: by appointment

Examination board
Chair-man:
Prof. Dr.-Ing. B.-A. Behrens
Contact Person:
Laura Lacatena
Im Moore 11 B (OK-Haus)
Tel.: +49 (0)511 762-4279
Fax.: +49 (0)511 762-3814
E-Mail: pa@maschinenbau.uni-hannover.de
Office hours:
Thu: 1000 – 1200 h

Threshold Workers Office
Chair-man:
Prof. Dr.-Ing. B.-A. Behrens
Secretary:
Laura Lacatena
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Wed: 1300 – 1600 h
Thu: 1400 – 1600 h
and by appointment

Dean's Office
Dean:
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Secretary:
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Office hours:
Mo – Fr: 900 – 1300 h
by appointment
### Institutes and Professors of the Faculty of Mechanical Engineering

#### Institute of Product Development
- **Prof. Dr.-Ing. R. Lachmayer**
  - Welfengarten 1 A
  - 30167 Hannover
  - Tel.: +49 (0)511 762-3472
  - Fax: +49 (0)511 762-4506
  - E-Mail: ipeg@ipeg.uni-hannover.de
  - Internet: www.ipeg.uni-hannover.de

#### Institute for Multiphase Processes
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  - Tel.: +49 (0)511 762-3828
  - Fax: +49 (0)511 762-3031
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  - Internet: www.imp.uni-hannover.de

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  - 30167 Hannover
  - Tel.: +49 (0)511 762-3334
  - Fax: +49 (0)511 762-3234
  - E-Mail: sekretariat@imr.uni-hannover.de
  - Internet: www.imr.uni-hannover.de

#### Institute of Micro Production Technology
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  - Hannover
  - An der Universität 2
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  - Fax: +49 (0)511 762-2867
  - E-Mail: impt@impt.uni-hannover.de
  - Internet: www.impt.uni-hannover.de

#### Institute of Transport- and Automation Technology
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  - Hannover
  - An der Universität 2
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  - Tel.: +49 (0)511 762-3524
  - Fax: +49 (0)511 762-4007
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  - Internet: www.ita.uni-hannover.de

#### Institute of Turbomachinery and Fluid Dynamics
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  - Fax: +49 (0)511 762-3997
  - E-Mail: info@tfd.uni-hannover.de
  - Internet: www.tfd.uni-hannover.de

#### Institute of Materials Science
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  - Hannover
  - An der Universität 2
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  - Fax: +49 (0)511 762-5245
  - E-Mail: office@iw.uni-hannover.de
  - Internet: www.iw.uni-hannover.de
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E-Mail: oest@nano.uni-hannover.de
Internet: http://www.fkp.uni-hannover.de

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Internet: http://www.iqo.uni-hannover.de

Max-Planck-Institute for Gravitational Physics
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Fax: +49 (0)511 762-2784
E-Mail: karsten.danzmann@aei.mpg.de
Internet: http://www.aei.mpg.de

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Institut für Informatikverarbeitung
Prof. Dr.-Ing. J. Ostermann
Appelstraße 9 A
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Tel: +49 (0)511 762-5316
Fax: +49(0)511 762-5333
E-Mail: ostermann@tnt.uni-hannover.de
Internet: http://www.tnt.uni-hannover.de

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(Servicehotline)
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Internet: www.uni-hannover.de/pruefungsamt
Contact person: Arne Sindermann
E-Mail: arne.sindermann@zuv.uni-hannover.de
Office hours:
Mo – Do: 1000 – 1230 h
Do: 1400 – 1600 h
Tel.: 
Mo – Do: 900 – 1700 h
Fr: 900 – 1500 h
Apart from office hours:
(at ServiceCenter)
Mo – Mi: 1230 – 1700 h
Do: 1230 – 1400 h and 1600 – 1700 h
Fr: 1000 – 1500 h

International Office
Wilhelm-Grunwald-Haus
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30167 Hannover
Tel: +49 (0)511 762-2548
Tel: +49 (0)511 762-2020
(Servicehotline)
Fax: +49 (0)511 762-4090
E-Mail: internationaloffice@uni-hannover.de
Internet: www.international.uni-hannover.de
Office hours:
Mo – Do: 1000 – 1230 h
Di und Do: 1400 – 1600 h
At ServiceCenter:
Mo – Do: 1000 – 1700 Uhr
Fr: 1000 – 1500 Uhr
International office:
(at ServiceCenter)
### Advice for Foreign Students at the Service Center:

<table>
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<tr>
<th>Day</th>
<th>Time</th>
<th>Activities</th>
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<tbody>
<tr>
<td>Mo</td>
<td>11:00 – 13:00</td>
<td>Guidance and advice of foreign students, postgraduates and visiting scientist</td>
</tr>
<tr>
<td>We</td>
<td>14:00 – 16:00</td>
<td>Registration for events and excursions</td>
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<tr>
<td>Th</td>
<td>10:00 – 13:00</td>
<td>ERASMUS Incomings, exchange students</td>
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</table>

### Matriculations Office

Welfengarten 1  
30167 Hannover  
Tel: +49 (0)511 762-2020  
(Servicehotline)  
E-Mail: studium@uni-hannover.de  
Internet: www.uni-hannover.de/i-amt  

Office hours (at ServiceCenter):  
Mo – Do: 10:00 – 17:00 h  
Fr: 10:00 – 15:00 h  
Tel.:  
Mo – Do: 9:00 – 17:00 h  
Fr: 9:00 – 15:00 h

### Service Center

Welfengarten 1 (Main building)  
30167 Hannover  
Tel: +49 (0)511 762-2020  
(Servicehotline)  
Fax: +49 (0)511 762-19385  
E-Mail: studium@uni-hannover.de  
Internet: www.uni-hannover.de/servicecenter/  

Office hours:  
Mo – Do: 10:00 – 17:00 h  
Fr: 10:00 – 15:00 h  
Tel.:  
Mo – Do: 9:00 – 17:00 h  
Fr: 9:00 – 15:00 h

---

**Student Advisory Office (ZSB)**

Welfengarten 1 (Hauptgebäude)  
30167 Hanover  
Tel. +49 (0)511 762-2020  
(Servicehotline)  
E-Mail: studienberatung@uni-hannover.de  
Internet: www.zsb.uni-hannover.de  

**Individual Counseling:**  
by appointment only:  
+49 (0)511 762-2020 (service hotline)  
Open consultation  
(Registration at the info desk)  
Th: 14:30 – 17:00  
Brief counseling (at the info desk, max. 10 minutes)  
Mo – Fr: 10:00 – 14:00  
Infothek (Materials for self information)  
Mo – Th: 10:00 – 17:00 Uhr  
Fr: 10:00 – 15:00 Uhr  
Telefonische Anfragen: (Service hotline: +49 511 762 2020)  
Mo – Fr: 9:00 – 15:00 Uhr
<table>
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<tr>
<td><strong>Hannover Centre for Optical Technologies (HOT)</strong></td>
</tr>
<tr>
<td>Prof. Dr. habil. Bernhard Roth</td>
</tr>
<tr>
<td>Nienburger Straße 17</td>
</tr>
<tr>
<td>30167 Hannover</td>
</tr>
<tr>
<td>Tel.: +49 (0)511 762-17908</td>
</tr>
<tr>
<td>Fax: +49 (0)511 762-17909</td>
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<tr>
<td>E-Mail: <a href="mailto:info@hot.uni-hannover.de">info@hot.uni-hannover.de</a></td>
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<td>Internet: <a href="http://www.hot.uni-hannover.de">www.hot.uni-hannover.de</a></td>
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<table>
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<tr>
<th><strong>Institut für Integrierte Produktion Hannover gGmbH (IPH)</strong></th>
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<tr>
<td>Managing Directors:</td>
</tr>
<tr>
<td>Prof. Dr.-Ing. B.-A. Behrens</td>
</tr>
<tr>
<td>Prof. Dr.-Ing. L. Overmeyer</td>
</tr>
<tr>
<td>Prof. Dr.-Ing. P. Nyhuis</td>
</tr>
<tr>
<td>Dr.-Ing. Georg Ullmann</td>
</tr>
<tr>
<td>Hollerithallee 6</td>
</tr>
<tr>
<td>30419 Hannover</td>
</tr>
<tr>
<td>Tel.: +49 (0)511 27976-0</td>
</tr>
<tr>
<td>Fax: +49 (0)511 27976-888</td>
</tr>
<tr>
<td>E-Mail: <a href="mailto:info@iph-hannover.de">info@iph-hannover.de</a></td>
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<table>
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<tr>
<th><strong>Laboratory of Nano and Quantum Engineering</strong></th>
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<tbody>
<tr>
<td>Dr. F. Schulze Wischelel</td>
</tr>
<tr>
<td>Schneiderberg 39</td>
</tr>
<tr>
<td>30167 Hannover</td>
</tr>
<tr>
<td>Tel.: +49 (0)511 762-16014</td>
</tr>
<tr>
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</tr>
<tr>
<td>E-Mail: <a href="mailto:schulze-wischeler@lnqe.uni-hannover.de">schulze-wischeler@lnqe.uni-hannover.de</a></td>
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<tr>
<td>Speaker of the board of directors:</td>
</tr>
<tr>
<td>Prof. Dr. R. Haug</td>
</tr>
<tr>
<td>Appelstraße 2</td>
</tr>
<tr>
<td>30167 Hannover</td>
</tr>
<tr>
<td>Tel.: +49 (0)511 762-2902</td>
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<tr>
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</tr>
<tr>
<td>E-Mail: <a href="mailto:haug@nano.uni-hannover.de">haug@nano.uni-hannover.de</a></td>
</tr>
<tr>
<td>Internet: <a href="http://www.lnqe.uni-hannover.de">www.lnqe.uni-hannover.de</a></td>
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<tr>
<th><strong>Laser Zentrum Hannover e.V. (LZH), Leibniz Universität Hannover</strong></th>
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<tr>
<td>Speaker of the board of directors:</td>
</tr>
<tr>
<td>Prof. Dr. Wolfgang Ertmer</td>
</tr>
<tr>
<td>Hollerithallee 8</td>
</tr>
<tr>
<td>30419 Hannover</td>
</tr>
<tr>
<td>Telefon: +49 (0)511 2788-0</td>
</tr>
<tr>
<td>Fax: +49 (0)511 2788-100</td>
</tr>
<tr>
<td>E-Mail: <a href="mailto:info@lzh.de">info@lzh.de</a></td>
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<td>Internet: <a href="http://www.lzh.de">www.lzh.de</a></td>
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<table>
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<tr>
<th><strong>Hannover Center of Mechatronics, Leibniz Universität Hannover</strong></th>
</tr>
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<tbody>
<tr>
<td>Dr.-Ing. Wolfgang Bartsch</td>
</tr>
<tr>
<td>Appelstraße 11</td>
</tr>
<tr>
<td>30167 Hannover</td>
</tr>
<tr>
<td>Tel.: +49 (0)511 762-4464</td>
</tr>
<tr>
<td>Fax: +49 (0)511 762-4536</td>
</tr>
<tr>
<td>E-Mail: <a href="mailto:mailbox@mzh.uni-hannover.de">mailbox@mzh.uni-hannover.de</a></td>
</tr>
<tr>
<td>Internet: <a href="http://www.mzh.uni-hannover.de">www.mzh.uni-hannover.de</a></td>
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<tr>
<td>Speaker of the board of directors:</td>
</tr>
<tr>
<td>Prof. Dr.-Ing. B. Ponick</td>
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<td>Tel.: +49 (0)511 762-2571</td>
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<tr>
<td>Fax: +49 (0)511 762-3040</td>
</tr>
<tr>
<td>E-Mail: <a href="mailto:ponick@ial.uni-hannover.de">ponick@ial.uni-hannover.de</a></td>
</tr>
<tr>
<td>Internet: <a href="http://www.mzh.uni-hannover.de">www.mzh.uni-hannover.de</a></td>
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<table>
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<tr>
<th><strong>Zentrum für Biomedizintechnik (zbm) of the Leibniz Universität Hannover</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Speaker of the board of directors:</td>
</tr>
<tr>
<td>Prof. Dr.-Ing. B. Glasmacher</td>
</tr>
<tr>
<td>Managing director:</td>
</tr>
<tr>
<td>Dipl.-Ing. G. Hohenhoff, M.Sc.</td>
</tr>
<tr>
<td>Callinstraße 36</td>
</tr>
<tr>
<td>30167 Hannover</td>
</tr>
<tr>
<td>Tel.: +49 (0)511 762-2786</td>
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<tr>
<td>Fax: +49 (0)511 762-3031</td>
</tr>
<tr>
<td>E-Mail: <a href="mailto:sekretariat@imp.uni-hannover.de">sekretariat@imp.uni-hannover.de</a></td>
</tr>
<tr>
<td>Internet: <a href="http://www.zbm.uni-hannover.de">www.zbm.uni-hannover.de</a></td>
</tr>
</tbody>
</table>
Centre for the Didactics of Engineering
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Tel.: +49 (0)511/762-5515
Fax: +49 (0)511/762-4012
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Internet: www.zdt.uni-hannover.de

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E-Mail: wolfgang.kowalsky@ihf.tu-bs.de
Internet: https://www.tu-braunschweig.de/ihf
## Appendix

### Objectives table of the master program Optical Technologies

<table>
<thead>
<tr>
<th>Important study goals</th>
<th>Competency goals in the sense of learning outcomes</th>
<th>Corresponding modules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic knowledge of physics</td>
<td>Basic principles (engineers) and further education (physicist) in the field of optics and related fields</td>
<td>Biophotonics&lt;br&gt;Laser Spectroscopy in Life Sciences&lt;br&gt;Optical Coatings&lt;br&gt;Photonics</td>
</tr>
<tr>
<td>Basic knowledge of engineering sciences</td>
<td>Basics (physicists) or specialization (engineers) in engineering sciences</td>
<td>Design of Optical Systems&lt;br&gt;Automotive Lighting&lt;br&gt;Optical Metrology&lt;br&gt;Augmented Reality Apps for Mechatronics and Medical Technology</td>
</tr>
<tr>
<td>Immersion or specialization in Optical Technologies</td>
<td>Getting detailed knowledge about modern optical technologies provided by a wide range of optic concerning lectures.</td>
<td>Compare selective module descriptions.</td>
</tr>
</tbody>
</table>
Diploma Supplement

This Diploma Supplement model was developed by the European Commission, Council of Europe and UNESCO/CEPES. The purpose of the supplement is to provide sufficient independent data to improve the international 'transparency' and fair academic and professional recognition of qualifications (diplomas, degrees, certificates etc.). It is designed to provide a description of the nature, level, context, content and status of the studies that were pursued and successfully completed by the individual named on the original qualification to which this supplement is appended. It should be free from any value judgements, equivalence statements or suggestions about recognition. Information in all eight sections should be provided. Where information is not provided, an explanation should give the reason why.

<table>
<thead>
<tr>
<th>Section</th>
<th>Details</th>
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</table>
| 1.      | 1.1 Family Name / 1.2 First Name  
1.3 Date, Place of Birth  
1.4 Student ID Number or Code |
| 2.      | 2.1 Name of Qualification (full, abbreviated; in original language)  
Master of Science in Optical Technologies, MSc  
Master of Science in Optische Technologien  
Title Conferred (full, abbreviated; in original language)  
Master of Science, MSc  
2.2 Main Field(s) of Study  
Mechanical Engineering, Physics |
| 2.3 Institution Awarding the Qualification (in original language)  
Gottfried Wilhelm Leibniz Universität Hannover  
Fakultät für Maschinenbau  
Status (Type / Control)  
University / State Institution |
| 2.4 Institution Administering Studies (in original language)  
[same]  
Status (Type / Control)  
[same] |
| 2.5 Language(s) of Instruction/Examination  
German |
3. LEVEL OF THE QUALIFICATION

3.1 Level
Second degree, research-oriented, including Master’s thesis

3.2 Official Length of Programme
Two years, 120 ECTS Credit Points

3.3 Access Requirements
Bachelor degree in Mechanical Engineering, Physics, Electrical Engineering or an equivalent first degree or foreign equivalent (see Sec. 8.4)

4. CONTENTS AND RESULTS GAINED

4.1 Mode of Study
Full-time programme

4.2 Programme Requirements/Qualification Profile of the Graduate
4.2.1 Qualification targets Master’s in Optical Technologies — Knowledge, Skills, Competencies
The degree course enables graduates to solve problems and to address issues in the field of optical technologies. In compulsory subjects, students on the programme learn not only engineering methods for solving problems and addressing issues, but also important principles of physics relevant to optical technologies. Elective competence areas round off the theoretical physics training with topics specific to engineering.

Practical training in the form of laboratory experiments and work experience in industry prepare students for their professional life in research firms in the optical industry. By writing a project report and a Master’s thesis, students acquire the skills required for conducting independent project work. The primary goals of this work include gaining experience in the planning and implementation of projects as well as learning how to draw up correct project documentation and presenting project results.

4.2.2 Learning results
Graduates of the Master’s programme are expected to have broad knowledge of optical technologies. To this end, students are taught knowledge, skills and methods that represent the state of the art, due to the high level of research conducted by the faculties involved. Industry internships, laboratory and project work, and the Master’s thesis enable students to gain experience in managing their own projects, working in a team, and exercising scientific responsibility within research activities.
In order to achieve these goals, the Master’s programme is divided into a basic field and several advanced optional fields. The basic field consists of field A “Physics” and field B “Engineering”.

4.4 Grading Scheme
See grading scheme in Sec. 8.6
4.5 Overall Classification (in original language)
«MPO_Gesamtnote_eng»

Based on weighted average of grades in examination fields.

\[
\text{Overall grade} = \frac{(\text{Grade for the examination} \times \text{respective CP}) + (\text{grade for the project work} \times 10 \text{ CP}) + (\text{grade for the Master's thesis} \times 30 \text{ CP})}{\text{Sum of CP for all graded examinations}}
\]
5. FUNCTION OF THE QUALIFICATION

5.1 Access to Further Study
The Master’s degree qualifies the graduate to apply for admission to doctoral studies.

5.2 Professional Status
The Master’s degree is the second degree in Mechanical Engineering that qualifies for a professional and scientific career.

6. ADDITIONAL INFORMATION

6.1 Additional Information
The Master of Science in Optical Technologies was accredited in 2014 by ASIIN (Accreditation Agency for Programmes in Engineering, Computer Science, Natural Sciences and Mathematics, www.asiin-ev.de).

6.2 Further Information Sources
About the university: www.uni-hannover.de
About the faculty: http://www.maschinenbau.uni-hannover.de/
About the study programme: http://www.maschinenbau.uni-hannover.de/480.html
Student Advice Service: http://www.uni-hannover.de/de/studium/studienfuehrer/optische-tech/

Contact:
Der Dekan der Fakultät für Maschinenbau
der Leibniz Universität Hannover
Im Moore 11b
30167 Hannover
Tel. ++49-511-762-2779
Fax ++49-511-762-2763

7. CERTIFICATION

This Diploma Supplement refers to the following original documents:
Urkunde über die Verleihung des Grades vom [Date]
Prüfungszeugnis vom [Date]

Certification Date: ________________
(Official Stamp/Seal)
Chairman Examination Committee

8. NATIONAL HIGHER EDUCATION SYSTEM

The information on the national higher education system on the following pages provides a context for the qualification and the type of higher education that awarded it.
8. INFORMATION ON THE GERMAN HIGHER EDUCATION SYSTEM

8.1 Types of Institutions and Institutional Status

Higher education (HE) studies in Germany are offered at three types of Higher Education Institutions (HEIs):

- Hochschulen (Universities) including various specialized institutions, offer the whole range of academic disciplines. In the German tradition, universities focus in particular on basic research so that advanced stages of study have mainly theoretical orientation and research-oriented components.

- Fachhochschulen (Universities of Applied Sciences) concentrate on their study programmes in engineering and other technical disciplines, business-related studies, social work, and design areas. The common mission of applied research and development implies a distinct application-oriented focus and professional character of studies, which include integrated and supervised work assignments in industry, enterprises or other relevant institutions.

- Kunst- und Musikhochschulen (Universities of Art/Music) offer studies for artistic careers in fine arts, performing arts and music; in such fields as directing, production, writing in theatre, film, and other media; and in a variety of design areas, architecture, media and communication.

Higher Education Institutions are either state or state-recognized institutions. In their operations, including the organization of studies and the designation and award of degrees, they are both subject to higher education legislation.

8.2 Types of Programmes and Degrees Awarded

Studies in all three types of institutions have traditionally been offered in integrated "long" (one-tier) programmes leading to Diplom- or Magister Artium degrees or completed by a Staatsprüfung (State Examination).

Within the framework of the Bologna-Process one-tier study programmes are successively being replaced by a two-tier study system. Since 1998, a scheme of first- and second-level degree programmes (Bachelor and Master) was introduced to be offered parallel to or instead of integrated "long" programmes. These programmes are designed to provide enlarged variety and flexibility to students in planning and pursuing educational objectives, they also enhance international comparability of studies.

The German Qualification Framework for Higher Education Degrees describes the degrees of the German Higher Education System. It contains the classification of the qualification levels as well as the resulting qualifications and competencies of the graduates.

For details cf. Sec. 8.4.1, 8.4.2, and 8.4.3 respectively. Table 1 provides a synoptic summary.

8.3 Approval/Accreditation of Programmes and Degrees

To ensure quality and comparability of qualifications, the organization of studies and general degree requirements have to conform to principles and regulations established by the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany (KMK). In 1999, a system of accreditation for programmes of study has become operational under the control of an Accreditation Council at national level. All new programmes have to be accredited under this scheme; after a successful accreditation they receive the quality-label of the Accreditation Council.
8.4 Organization and Structure of Studies

The following programmes apply to all three types of institutions. Bachelor's and Master's study courses may be studied consecutively, at various higher education institutions, at different types of higher education institutions and with phases of professional work between the first and the second qualification. The organization of the study programmes makes use of modular components and of the European Credit Transfer and Accumulation System (ECTS) with 30 credits corresponding to one semester.

8.4.1 Bachelor

Bachelor degree study programmes lay the academic foundations, provide methodological skills and lead to qualifications related to the professional field. The Bachelor degree is awarded after 3 to 4 years.

The Bachelor degree programme includes a thesis requirement. Study courses leading to the Bachelor degree must be accredited according to the Law establishing a Foundation for the Accreditation of Study Programmes in Germany.¹

First degree programmes (Bachelor) lead to Bachelor of Arts (B.A.), Bachelor of Science (B.Sc.), Bachelor of Engineering (B.Eng.), Bachelor of Laws (LL.B.), Bachelor of Fine Arts (B.F.A.), Bachelor of Music (B.Mus.) or Bachelor of Education (B.Ed.).

8.4.2 Master

Master is the second degree after another 1 to 2 years. Master study programmes may be differentiated by the profile types "practice-oriented" and "research-oriented". Higher Education Institutions define the profile.

The Master degree study programme includes a thesis requirement. Study programmes leading to the Master degree must be accredited according to the Law establishing a Foundation for the Accreditation of Study Programmes in Germany.¹

Second degree programmes (Master) lead to Master of Arts (M.A.), Master of Science (M.Sc.), Master of Engineering (M.Eng.), Master of Laws (LL.M.), Master of Fine Arts (M.F.A.), Master of Music (M.Mus.) or Master of Education (M.Ed.). Master study programmes which are designed for continuing education may carry other designations (e.g. MBA).

8.4.3 Integrated "Long" Programmes (One-Tier):

Diplom degrees, Magister Artium, Staatsprüfung

An integrated study programme is either mono-disciplinary (Diplom degrees, most programmes completed by a Staatsprüfung) or comprises a combination of either two major or one major and two minor fields (Magister Artium). The first stage (1.5 to 2 years) focuses on broad orientations and foundations of the field(s) of study. An Intermediate Examination (Diplom-Vorprüfung for Diplom degrees; Zwischenprüfung or credit requirements for the Magister Artium) is prerequisite to enter the second stage of advanced studies and specializations. Degree requirements include submission of a thesis (up to 6 months duration) and comprehensive final written and oral examinations. Similar regulations apply to studies leading to a Staatsprüfung. The level of qualification is equivalent to the Master level.

- Integrated studies at Universitäten (U) last 4 to 5 years (Diplom degree, Magister Artium) or 3 to 6.5 years (Staatsprüfung). The Diploma degree is awarded in engineering disciplines, the natural sciences as well as economics and business. In the humanities, the corresponding degree is usually the Magister Artium (M.A.). In the social sciences, the practice varies as a matter of institutional traditions. Studies preparing for the legal, medical and pharmaceutical professions are completed by a Staatsprüfung. This applies also to studies preparing for teaching professions of some Länder.

The three qualifications (Diplom, Magister Artium and Staatsprüfung) are academically equivalent. They qualify to apply for admission to doctoral studies. Further prerequisites for admission may be defined by the Higher Education Institution, cf. Sec. 8.5.

- Integrated studies at Fachhochschulen (FH)/Universities of Applied Sciences (UAS) last 4 years and lead to a Diplom (FH) degree. While the FH-UAS are non-doctorate granting institutions, qualified graduates may apply for admission to doctoral studies at doctorate-granting institutions, cf. Sec. 8.5.

- Studies at Kunsthochschulen (Universities of Art/Music etc.) are more diverse in their organization, depending on the field and individual objectives. In addition to Diplom/Magister degrees, the integrated study programme awards include Certificates and certified examinations for specialized areas and professional purposes.

8.5 Doctorate

Universities as well as specialized institutions of university standing and some Universities of Art/Music are doctorate-granting institutions. Formal prerequisite for admission to doctoral work is a qualified Master (UAS and U), a Magister degree, a Diplom, a Staatsprüfung, or a foreign equivalent. Particulally qualified holders of a Bachelor or a Diplom (FH) degree may also be admitted to doctoral studies without acquisition of a further degree by means of a procedure to determine their aptitude. The universities respectively the doctorate-granting institutions regulate entry to a doctorate as well as the structure of the procedure to determine aptitude. Admission further requires the acceptance of the Dissertation research project by a professor as a supervisor.

8.6 Grading Scheme

The grading scheme in Germany usually comprises five levels (with numerical equivalents; intermediate grades may be given): “Sehr Gut” (1) = Very Good; “Gut” (2) = Good; “Befriedigend” (3) = Satisfactory; “Auffallend” (4) = Sufficient; “Nicht ausreichend” (5) = Non-Sufficient/Fail. The minimum passing grade is "Auffallend" (4). Verbal designations of grades may vary in some cases and for doctoral degrees.

In addition institutions partly already use an ECTS grading scheme.

8.7 Access to Higher Education

The General Higher Education Entrance Qualification (Allgemeine Hochschulreife, Abitur) after 12 to 13 years of schooling allows for admission to all higher educational studies. Specialized variants (Fachgebundene Hochschulreife) allow for admission to particular disciplines. Access to Fachhochschulen (UAS) is also possible with a Fachhochschulreife, which can usually be acquired after 12 years of schooling. Admission to Universities of Art/Music may be based on other or require additional evidence demonstrating individual aptitude.

Higher Education Institutions may in certain cases apply additional admission procedures.
8.8 National Sources of Information

- Kultusministerkonferenz (KMK) [Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany]; Lennéstrasse 6, D-53113 Bonn; Fax: +49(0)228/501-229; Phone: +49(0)228/501-0
- Central Office for Foreign Education (ZaB) as German NARIC; www.kmk.org; E-Mail: zab@kmk.org
- "Documentation and Educational Information Service" as German EURYDICE-Unit, providing the national dossier on the education system europaeischer-ebene-im-eurydice-informationsnetz.html; E-Mail: eurydice@kmk.org
- Hochschulrektorenkonferenz (HRK) [German Rectors’ Conference]; Ahrstrasse 39, D-53175 Bonn; Fax: +49(0)228/887-110; Phone: +49(0)228/887-0; www.hrk.de; E-Mail: post@hrk.de
- "Higher Education Compass" of the German Rectors’ Conference features comprehensive information on institutions, programmes of study, etc. [www.higher-education-compass.de](http://www.kmk.org/dokumentation/zusammenarbeit-auf-europaeischer-ebene-im-eurydice-informationsnetz.html)

1 The information covers only aspects directly relevant to purposes of the Diploma Supplement. All information as of 1 July 2010.
2 Berufsakademien are not considered as Higher Education Institutions; they only exist in some of the Länder. They offer educational programmes in close cooperation with private companies. Students receive a formal degree and carry out an apprenticeship at the company. Some Berufsakademien offer Bachelor courses which are recognized as an academic degree if they are accredited by a German accreditation agency.
4 Common structural guidelines of the Länder for the accreditation of Bachelor’s and Master’s study courses (Resolution of the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany of 10.10.2003, as amended on 04.02.2010).
6 See note No. 5.
7 See note No. 5.