

**Technology**  
**Arts Sciences**  
**TH Köln**

Faculty of Information, Media and Electrical Engineering

## **Master Electrical Engineering and Information Technology PO1**

### **Module Manual**

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The most recent version of this handbook can be found here:

<https://f07-studieninfo.web.th-koeln.de/mhb/current/en/MaET2024.html>

# 1. Program Description

The Master of Science in Electrical Engineering and Information Technology is a three-semester course of study that builds consecutively on the Bachelor of Science in Electrical Engineering and Information Technology. It enables students to carry out independent scientific work in the field of electrical engineering. Building on practice-oriented study profiles, the Master's degree course in Electrical Engineering enables students to expand their basic knowledge in a scientifically sound manner and to specialize in a particular field.

## Orientation of the degree program

An important first goal of the Master's degree course is to consolidate and deepen the basic knowledge acquired in the Bachelor's degree course. The next step is to specialize in one of the three key disciplines of automation technology, electrical energy technology and optical technologies. In addition, students will learn how to summarize, evaluate and present complex technical processes and systems as well as their economic significance. This is also done in English. The quality assurance of the degree program is carried out by the Standing Committee for Teaching, Studies and Academic Reform at TH Köln.

## Occupational fields

Graduates have qualifications that open up a wide range of career opportunities. Without claiming to be exhaustive, hardware and / or software-oriented fields of activity are, for example

- in (electrical) automotive engineering,
- medical technology and biotechnology,
- in the entire consumer goods industry
- in production
- in the chemical industry
- in the area of public supply and infrastructure,
- in the field of energy generation, distribution and supply,
- in environmental protection,
- as well as in the fields of information and communication technologies.

You will be able to make independent scientific contributions in your specialist area and you will be able to familiarize yourself independently with new specialist areas. You are therefore particularly suited to working in research and development departments. Due to your extensive basic knowledge, you may also be able to work in interdisciplinary teams. You will be prepared for management positions in industry as well as positions in the senior civil service of public institutions. Graduates with very good degrees have good prospects of successfully applying for doctoral positions at technical colleges or universities. The specializations in automation technology, electrical power engineering and optical technologies open up a very broad spectrum of professional fields, not only in the electrical engineering industry. Prerequisite for admission to the program is a qualified degree in electrical engineering with a Bachelor of Engineering or Bachelor of Science degree. Proof of qualification should generally be a qualified first degree with 210 ECTS credit points and an overall grade of 2.5 or better (further details can be found in the examination and enrolment regulations). Prospective students with a Bachelor's degree in a related subject area can also apply and may receive admission with conditions.

## Study requirements

A qualified degree in electrical engineering with a Bachelor of Engineering or Bachelor of Science degree is a prerequisite for admission to the course. Proof of qualification should generally be a qualified first degree with 210 ECTS credit points and an overall grade of 2.5 or better (further details can be found in the examination and enrolment regulations). Prospective students with a Bachelor's degree in a related subject area can also apply and may receive admission with conditions.

## Course of study

The degree program has a modular structure and the modules and courses are assessed according to the European Credit Transfer System (ECTS). This facilitates international student exchange. The course is worth a total of 90 ECTS points. In accordance with the objectives of the Master's degree course in Electrical Engineering and Information Technology, knowledge is imparted in four blocks, each comprising several modules: - Fundamentals (three compulsory modules) - Specialist profiling through three modules in either Automation Technology, Electrical Power Engineering or Optical Technologies - Three further electives - Work in a project context: This includes activities in a project management role, the research seminar with the element of specialist discourse and finally the Master's thesis with colloquium

## 2. Graduate Profile

Graduates of the M. Sc. Electrical Engineering and Information Technology degree program are able to independently master demanding, interdisciplinary challenges in research, development and management. They design, evaluate and implement complex technical systems at a scientific level. Building on the foundations of the Bachelor's degree, they expand and deepen their skills through research- and project-oriented work in the areas of automation technology, electrical power engineering or optical technologies. They are thus excellently qualified for leading positions in industry, research and public infrastructure as well as for a doctorate.

The aim of the M. Sc. in Electrical Engineering and Information Technology is to build on the broad engineering foundation of the Bachelor's degree and to systematically expand it through scientifically sound specialization, independent research and interdisciplinary skills.

In contrast to the Bachelor's degree course, which focuses on application-oriented basic training, the Master's degree course focuses on the research-based design, evaluation and sustainable management of complex technical systems. Graduates work in an interdisciplinary, systemic and reflective manner - both in the depth of the specialist field and in related scientific and social contexts.

As part of the degree program, graduates develop an individual profile in the following areas:

- They are able to design and simulate technical systems from a scientific point of view and evaluate them in their entirety - taking into account technical, economic and ethical aspects.
- You will be able to plan, manage and carry out interdisciplinary research and development projects, particularly in complex subject areas such as autonomous control, sustainable energy supply or high-tech optical systems.
- They have sound skills in scientific work - including literature work, application of methods, hypothesis formation and critical presentation of results - and are therefore ideally prepared for a doctorate.
- They master modern tools for modeling, simulation, quality assurance and project management and apply these in a targeted manner in innovative development environments.
- Graduates take on responsibility in specialist management roles and actively shape technical and social transformation processes - for example in the energy sector, mobility or medical technology.
- They operate confidently in an international environment and can communicate technical content in German and English in a manner appropriate to the target audience.
- The specialization in one of the key areas of automation technology, electrical energy technology or optical technologies allows a targeted specialization that can be transferred to a wide range of professional fields - from research & development to strategic technology management.

### 3. Fields of Action

Central fields of activity in the degree program are development and design, research and innovation, leadership and management as well as quality assurance and testing. The profile module matrix shows which fields of activity are addressed by which modules.

#### **Development and Design**

Interdisciplinary development and testing of algorithms, circuits, software, devices, communication and media technology systems as well as complex computer, communication and embedded systems.

#### **Research and innovation**

Perform scientific research work and apply and expand scientific knowledge, from basic research to industrial research, with the qualification for doctoral studies.

#### **Leadership and management**

Assume technical leadership and project responsibility, including the coordination and management of working groups and internationally distributed teams, as well as the management of planning and manufacturing processes, project controlling and product management.

#### **Quality assurance and testing**

Carrying out quality controls and tests for products and processes, using measurement and testing technologies and coordinating certification processes.

## 4. Competencies

The modules of the degree program train students in different competencies, which are described below. The [Profile Module Matrix] (#Module Matrix) shows which competences are addressed by which modules.

### **Development and design of complex systems**

Ability to design and implement large systems, taking into account electrical, software, mechanical and optical aspects, based on a thorough requirements analysis from a technical, economic, ecological and social point of view.

### **Testing and evaluation of complex systems**

Plan, perform and analyze tests to verify and validate these systems, including consideration of user perspectives and technical-economic aspects.

### **Scientific work and research**

Mastery and application of scientific methods, including the ability to research, evaluate and cite relevant literature, and to formulate and present results.

### **Project management and teamwork**

Skills in organizing, managing and supervising projects and teams, even under uncertain conditions, and in making professional and organizational decisions.

### **Self-organization and self-taught skills**

Identification of personal skills, efficient time management and the ability for self-directed learning.

### **Communication and intercultural competence**

Ability to present and defend scientific and technical results convincingly in both German and English, including international and interdisciplinary contexts.

### **Technical and scientific fundamentals**

Comprehensive and in-depth STEM subject knowledge and its application to real-world and theoretical problems.

### **Sustainability and social responsibility**

Evaluate and develop sustainable and socially responsible technologies, including consideration of ethical values.

### **Analysis, simulation and abstraction**

Ability to analyze complex systems, abstract key features and solve problems based on models.

### **Leadership and decision-making responsibility**

Assume responsibility in technical management tasks, develop solution strategies for complex tasks.

### **Applying ethical values and principles in practice**

Incorporating social and ethical considerations into technical decisions and design processes.

### **Integrative thinking and acting in interdisciplinary teams**

Coordinating and integrating contributions from different disciplines to solve complex tasks.

### **Innovation and creativity**

Developing new solutions and concepts to overcome technical challenges.

## 5. Study Plans

The following are studyable study plans. Other study plans are also possible. Please note, however, that each module is usually only offered once a year. Please also note that several modules may have to be selected in a particular semester and elective catalogs in order to obtain the total ECTS credit points shown.

### 5.1 Studienverlaufsplan

| Sem. | Abbr. | Name                                                     | Catalog (WB)<br>Elective<br>Mandatory (PF) | ECTS |
|------|-------|----------------------------------------------------------|--------------------------------------------|------|
| 1    | HIM   | Advanced Mathematics                                     | PF                                         | 5    |
|      | PLET  | Projektleitung                                           | PF                                         | 5    |
|      | BTH   | Beliebiges Modul aus einem Masterstudiengang der TH Köln | WB                                         | 5    |
|      | SV    | Studienschwerpunktmodule                                 | WB                                         | 10   |
|      | WM    | Allgemeiner Wahlmodulbereich                             | WB                                         | 5    |
| 2    | FS    | Forschungsseminar                                        | PF                                         | 10   |
|      | SIM   | Simulation in der Ingenieurwissenschaft                  | PF                                         | 5    |
|      | TED   | Theoretische Elektrodynamik                              | PF                                         | 5    |
|      | SV    | Studienschwerpunktmodule                                 | WB                                         | 5    |
|      | WM    | Allgemeiner Wahlmodulbereich                             | WB                                         | 5    |
| 3    | KOLL  | Kolloquium zur Masterarbeit                              | PF                                         | 3    |
|      | MAA   | Masterarbeit                                             | PF                                         | 27   |

## 5.2 Alternativer Studienverlaufsplan

| Sem. | Abbr. | Name                                                     | Catalog (WB)<br>Elective<br>Mandatory (PF) | ECTS |
|------|-------|----------------------------------------------------------|--------------------------------------------|------|
| 1    | SV    | Studienschwerpunktmodule                                 | WB                                         | 5    |
|      | WM    | Allgemeiner Wahlmodulbereich                             | WB                                         | 5    |
|      | TED   | Theoretische Elektrodynamik                              | PF                                         | 5    |
| 2    | SV    | Studienschwerpunktmodule                                 | WB                                         | 5    |
|      | HIM   | Advanced Mathematics                                     | PF                                         | 5    |
|      | WM    | Allgemeiner Wahlmodulbereich                             | WB                                         | 5    |
| 3    | FS    | Forschungsseminar                                        | PF                                         | 10   |
|      | SIM   | Simulation in der Ingenieurwissenschaft                  | PF                                         | 5    |
| 4    | PLET  | Projektleitung                                           | PF                                         | 5    |
|      | BTH   | Beliebiges Modul aus einem Masterstudiengang der TH Köln | WB                                         | 5    |
|      | SV    | Studienschwerpunktmodule                                 | WB                                         | 5    |
| 5    | KOLL  | Kolloquium zur Masterarbeit                              | PF                                         | 3    |
|      | MAA   | Masterarbeit                                             | PF                                         | 27   |

## 6. Modules

The modules of the degree program are described below in alphabetical order.

### 6.1 ACC - Advanced Channel Coding

|                             |                                              |
|-----------------------------|----------------------------------------------|
| <b>Module ID</b>            | ACC                                          |
| <b>Module Name</b>          | Advanced Channel Coding                      |
| <b>Type of Module</b>       | Elective Modules                             |
| <b>Recognized Course</b>    | ACC - Advanced Channel Coding                |
| <b>ECTS credits</b>         | 5                                            |
| <b>Language</b>             | englisch                                     |
| <b>Duration of Module</b>   | 1 Semester                                   |
| <b>Recommended Semester</b> | 1-2                                          |
| <b>Frequency of Course</b>  | every summer term                            |
| <b>Module Coordinator</b>   | Prof. Dr. Uwe Dettmar/Professor Fakultät IME |
| <b>Lecturer(s)</b>          | Prof. Dr. Uwe Dettmar/Professor Fakultät IME |

#### Learning Outcome(s)

What? Designing and rating of systems for the reliable transmission of data over distorted channels and storage of data for data at rest and data in motion

How? By applying results from information theory and applying methods and algorithms for error correcting codes using existing simulations tools, self written programmes, and studying existing systems.

What for? To be able to design, select, use and apply actual and future digital communication systems for reliable data transmission, and to rate their performance.



## Module Contents

### Lecture / Exercises

The underlying concept of this module is a combination from lecture and tutorial. After a lecture block of approximately 20 minutes) the subjects taught are actively trained using Matlab/Octave and Python programs.

Syllabus:

- Introduction
- Basic terms and definitions
- short history of channel coding
- System and channel models
- Review of binary error correcting block and convolutional Codes
- Generator and Parity check matrices,
- decoding principles, Trellis and Viterbi Algorithm
- Some principles on Information Theory
- Channel coding theorem
- Channel capacity and example calculations
- Cyclic Codes, Reed Solomon Codes
- Encoding and Decoding, Euclidean and Berlekamp-Massey -Algorithm for Decoding
- Basics on LDPC, Polar, and TURBO Codes
- iterative decoding, Sum Product Algorithm
- Recursive Convolutional Codes
- Performance comparison
- Basics on Space Time Coding
- Channel Model, Capacity improvement, Alamouti Scheme, STBC and STTC and their decoding

These subjects are presented during the lecture. Students shall deepen their knowledge by self-study of literature and internet resources and discuss their results in small learning groups as a teamwork.

By the help of small exercises and programs during the presence time, students are able to actively train their knowledge. More extensive problems are solved and discussed in the second part of the course to activate the student's capabilities to solve relevant problems.

Students further learn

- to analyze communication systems and to estimate their performance
- to compare and rate algorithms and methods
- to apply their knowledge to technical problems

### Lab

Existing simulation Tools like, e.g., the Matlab Communications Toolbox or AFF3CT ([aff3ct.github.io](https://aff3ct.github.io)) are used to:

- test theoretical results from lecture and tutorial
- implement algorithms for error control coding
- simulate BER and rate the performance, compare schemes
- adapt programs to solve equivalent problems
- become familiar with standard simulations tools
- train cooperation in small teams

Students learn to generate, check, present, and discuss performance results for FEC codes. They need to search for and to study scientific literature as background sources for their simulations. Teams of students get different code families to study. Results are presented to the whole group.

|                              |                       |
|------------------------------|-----------------------|
| <b>Teaching and Learning</b> | ▪ Lecture / Exercises |
| <b>Methods</b>               | ▪ Lab                 |

|                                       |                                                                                                                                                      |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Examination Types with Weights</b> | ▪ accompanying: oral contribution or exercise lab under exam conditions [ungraded] and<br>▪ final: (digital) written exam or oral examination [100%] |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|

|                 |           |
|-----------------|-----------|
| <b>Workload</b> | 150 Hours |
|-----------------|-----------|

|                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Contact Hours</b>                             | 45 Hours $\triangleq$ 4 SWS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Self-Study</b>                                | 105 Hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Recommended Prerequisites</b>                 | <ul style="list-style-type: none"> <li>▪ Modul HIM: Grundkenntnisse zur linearen Algebra, der Algebra in endlichen Zahlkörpern, der Stochastik und der digitalen Kommunikationstechnik aus den vorangegangenen Bachelorstudiengängen. Da das Fach im ersten Fachsemester des Masters gewählt werden kann, können keine belastbaren Kenntnisse aus dem Fach HIM verpflichtend vorausgesetzt werden, auch wenn sie hilfreich wären.</li> <li>▪ basics in linear algebra</li> <li>▪ basics in stochastics</li> <li>▪ good programming skills</li> </ul>                                                                         |
| <b>Mandatory Prerequisites</b>                   | <ul style="list-style-type: none"> <li>▪ Lab requires attendance in the amount of: 2 Praktikumstermine und 1 Präsentation</li> <li>▪ Participation in final examination only after successful participation in Lab</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"> <li>▪ R. E. Blahut. Algebraic Codes for Data Transmission. Cambridge University Press, Cambridge, 2003.</li> <li>▪ S. Lin and D. J. Costello. Error Control Coding. ISBN 0-13-042672-5. Prentice-Hall, 2004</li> <li>▪ T. M. Cover and J. A. Thomas. Elements of Information Theory. Wiley, New Jersey, 2006</li> <li>▪ A. Neubauer. Kanalcodierung. Schlembach, Wilburgstetten, 2006.</li> <li>▪ R. Roth. Introduction to Coding Theory. Cambridge, second edition, 2006</li> <li>▪ B. Sklar. Digital Communications. Prentice Hall PTR, Upper Saddle River, New Jersey, 2001</li> </ul> |
| <b>Included in Elective Catalog</b>              | WM - Allgemeiner Wahlmodulbereich                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Included in Specialization</b>                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"> <li>▪ ACC in Master Communication Systems and Networks PO3</li> <li>▪ ACC in Master Communication Systems and Networks PO4</li> <li>▪ ACC in Master Technische Informatik PO3</li> <li>▪ ACC in Master Informatik und Systems-Engineering PO1</li> </ul>                                                                                                                                                                                                                                                                                                                                  |
| <b>Permanent Links to Organization</b>           | <a href="#">ILU course page</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Last Update</b>                               | 19.7.2025, 14:32:16                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

## 6.2 BSN - Basics on Systems and Networks

|                             |                                                                                                                                                                                                                               |
|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Module ID</b>            | BSN                                                                                                                                                                                                                           |
| <b>Module Name</b>          | Basics on Systems and Networks                                                                                                                                                                                                |
| <b>Type of Module</b>       | Elective Modules                                                                                                                                                                                                              |
| <b>Recognized Course</b>    | BSN - Basics on Systems and Networks                                                                                                                                                                                          |
| <b>ECTS credits</b>         | 5                                                                                                                                                                                                                             |
| <b>Language</b>             | englisch                                                                                                                                                                                                                      |
| <b>Duration of Module</b>   | 1 Semester                                                                                                                                                                                                                    |
| <b>Recommended Semester</b> | 1-2                                                                                                                                                                                                                           |
| <b>Frequency of Course</b>  | every summer term                                                                                                                                                                                                             |
| <b>Module Coordinator</b>   | Prof. Dr. Rainer Kronberger/Professor Fakultät IME                                                                                                                                                                            |
| <b>Lecturer(s)</b>          | <ul style="list-style-type: none"> <li>▪ Prof. Dr. Rainer Kronberger/Professor Fakultät IME</li> <li>▪ Prof. Dr. Harald Elders-Boll/Professor Fakultät IME</li> <li>▪ Prof. Dr. Uwe Dettmar/Professor Fakultät IME</li> </ul> |

### Learning Outcome(s)

Students learn the basics of communication systems and networks, by means of lectures, tutorials, exercises and practical laboratory experiments, so that they can later develop, design, analyze, measure and set up communication technology components, systems and networks.

### Module Contents

#### Lecture

Introduction to Digital Communication Systems and Networks  
 Review of the Basics: Signals and Systems  
 Review of the Basics: Probability Theory  
 Representation of Bandpass Signals and Systems  
 Signals, Noise, Electromagnetic Waves  
 Wave Propagation  
 Communication Components: Receiver and Transmitter  
 Antennas  
 Source Coding and Quantization  
 Channel Coding and Cryptography  
 Modulation  
 OFDM  
 Radio Standards and Mobile Communication Systems and Networks

#### Exercises / Lab

Lab: Binary NRZ, IQ-Modulation and Demodulation  
 Lab: Channel Coding and QPSK Modulation  
 Lab: RF Signals

**Teaching and Learning Methods**

- Lecture
- Exercises / Lab

|                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Examination Types with Weights</b>            | <ul style="list-style-type: none"> <li>■ accompanying: (intermediate) certificate [ungraded] and</li> <li>■ final: (digital) written exam or oral examination [100%]</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Workload</b>                                  | 150 Hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Contact Hours</b>                             | 45 Hours $\triangleq$ 4 SWS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Self-Study</b>                                | 105 Hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Recommended Prerequisites</b>                 | Basics in communications, electronics, information technologies                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Mandatory Prerequisites</b>                   | <ul style="list-style-type: none"> <li>■ Exercises / Lab requires attendance in the amount of: 3 Testattermine</li> <li>■ Participation in final examination only after successful participation in Exercises / Lab</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"> <li>■ Tolga M. Duman, Fundamentals of Digital Communication Systems, Cambridge University Press, 2025</li> <li>■ John Proakis and Masoud Salehi. Digital Communications. 5th. McGraw-Hill, 2007</li> <li>■ Michael Rice. Digital Communications: A Discrete-Time Approach. Pearson Prentice Hall, 2009.</li> <li>■ James Kurose and Keith Ross. Computer Networking A Top Down Approach. 7th ed. Pearson, 2016.</li> <li>■ Andrew S. Tanenbaum, Nick Feamster, and David J. Wetherall. Computer Networks. 6th ed. Pearson, 2021.</li> <li>■ Ha H. Nguyen and Ed Shwedyk. A First Course in Digital Communications. Cambridge University Press, 2009.</li> <li>■ Upamanyu Madhow. Fundamentals of Digital Communication. Cambridge University Press, 2008.</li> </ul> |
| <b>Included in Elective Catalog</b>              | WM - Allgemeiner Wahlmodulbereich                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Included in Specialization</b>                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"> <li>■ BSN in Master Communication Systems and Networks PO3</li> <li>■ BSN in Master Communication Systems and Networks PO4</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Permanent Links to Organization</b>           | <a href="#">Link for the learning platform</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Last Update</b>                               | 4.9.2025, 13:14:17                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

### 6.3 CSO - Computersimulation in der Optik

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Module ID</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | CSO                                                                                                                                                                                                                                        |
| <b>Module Name</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Computersimulation in der Optik                                                                                                                                                                                                            |
| <b>Type of Module</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Elective Modules                                                                                                                                                                                                                           |
| <b>Recognized Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | CSO - Computersimulation in der Optik                                                                                                                                                                                                      |
| <b>ECTS credits</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 5                                                                                                                                                                                                                                          |
| <b>Language</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | deutsch und englisch                                                                                                                                                                                                                       |
| <b>Duration of Module</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 1 Semester                                                                                                                                                                                                                                 |
| <b>Recommended Semester</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 1-2                                                                                                                                                                                                                                        |
| <b>Frequency of Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | every winter term                                                                                                                                                                                                                          |
| <b>Module Coordinator</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Prof. Dr. Holger Weigand/Professor Fakultät IME                                                                                                                                                                                            |
| <b>Lecturer(s)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Prof. Dr. Holger Weigand/Professor Fakultät IME                                                                                                                                                                                            |
| <b>Learning Outcome(s)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                            |
| <p>Kompetenz zum Aufbau, zur Analyse, zur Optimierung und Auslegung beleuchtungsoptischer Systeme unter Zuhilfenahme von Software basierend auf nicht-sequentiellm Raytrace.</p> <p>Kompetenz für Software-Entwicklung im Umfeld der Computersimulation (Makro-Programmierung mit Skript-Sprachen, z.B. zum Steuern des In- oder Outputs von Simulationen).</p> <p>Kompetenz zum Erwerb vertiefter Fertigkeiten im Bereich nicht-sequentieller Raytrace-Simulation durch eigenständiges Durcharbeiten von Literatur und Software-Dokumentation, sowie der Einbeziehung des technischen Supports der Software zu einer speziellen Thematik.</p> |                                                                                                                                                                                                                                            |
| <b>Module Contents</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                            |
| <b>Lecture / Exercises</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                            |
| <br>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                            |
| <b>Lab</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                            |
| <br>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                            |
| <b>Project</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                            |
| <br>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                            |
| <b>Teaching and Learning Methods</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <ul style="list-style-type: none"> <li>▪ Lecture / Exercises</li> <li>▪ Lab</li> <li>▪ Project</li> </ul>                                                                                                                                  |
| <b>Examination Types with Weights</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <ul style="list-style-type: none"> <li>▪ accompanying: (intermediate) certificate [ungraded] and</li> <li>▪ final: project work [100%]</li> </ul>                                                                                          |
| <b>Workload</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 150 Hours                                                                                                                                                                                                                                  |
| <b>Contact Hours</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 57 Hours $\pm$ 5 SWS                                                                                                                                                                                                                       |
| <b>Self-Study</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 93 Hours                                                                                                                                                                                                                                   |
| <b>Recommended Prerequisites</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                            |
| <b>Mandatory Prerequisites</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <ul style="list-style-type: none"> <li>▪ Participation in final examination only after successful participation in Lecture / Exercises</li> <li>▪ Participation in final examination only after successful participation in Lab</li> </ul> |

|                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"><li>■ W. T. Welford, R. Winston: High Collection Nonimaging Optics, Academic Press, 1989; G. Kloos: Entwurf und Auslegung optischer Reflektoren, Expert, 2007; Deutsche und US-Amerikanische Patentschriften; Datenblätter optischer und opto-elektronischer Komponenten; MIT Scheme Reference, Edition 1.62, 1996 (<a href="https://groups.csail.mit.edu/mac/ftpd/ftpdir/scheme-7.4/doc-html/scheme_toc.html">https://groups.csail.mit.edu/mac/ftpd/ftpdir/scheme-7.4/doc-html/scheme_toc.html</a>); H. Ramchandran, A. S. Nair: Scilab (a Free Software to Matlab), S. Chand, 2012; F. Thuselt, F. P. Gennrich: Praktische Mathematik mit MATLAB, Scilab und Octave, Springer 2013; T. Sheth: SCILAB: A Practical Introduction to Programming and Problem Solving, CreateSpace, 2016; C. Gomez: Engineering and Scientific Computing with Scilab, Birkhäuser, 1999;</li></ul> |
| <b>Included in Elective Catalog</b>              | <ul style="list-style-type: none"><li>■ SV - Studienschwerpunktmodule</li><li>■ WM - Allgemeiner Wahlmodulbereich</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Included in Specialization</b>                | OT - Optische Technologien                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"><li>■ CSO in Master Communication Systems and Networks PO3</li><li>■ CSO in Master Communication Systems and Networks PO4</li><li>■ CSO in Master Elektrotechnik PO3</li><li>■ CSO in Master Technische Informatik PO3</li><li>■ CSO in Master Informatik und Systems-Engineering PO1</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Last Update</b>                               | 5.9.2025, 17:36:59                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

## 6.4 DLO - Deep Learning und Objekterkennung

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Module ID</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | DLO                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Module Name</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Deep Learning und Objekterkennung                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Type of Module</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Elective Modules                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Recognized Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | DLO - image processing master                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>ECTS credits</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Language</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | deutsch                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Duration of Module</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1 Semester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Recommended Semester</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 1-2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Frequency of Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | every summer term                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Module Coordinator</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Prof. Dr. Jan Salmen/Professor Fakultät IME                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Lecturer(s)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Prof. Dr. Jan Salmen/Professor Fakultät IME                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Learning Outcome(s)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <p>Die Teilnehmer*innen können selbständig entscheiden, in welchen Situationen sich der Einsatz von Verfahren aus dem Bereich Deep Learning anbietet. Sie können eine entsprechende Lösung entwerfen, iterativ verbessern und praktisch umsetzen. Mögliche Probleme auf dem Weg dahin (z.B. beim Erstellen eines Datensatzes oder beim Training) können sie qualifiziert analysieren und passende Ideen zur Bewältigung entwickeln. Da sie einen guten Überblick über die langjährigen Entwicklungen in Forschung und Technik haben, können sie qualifiziert auf aktuelle Herausforderungen und offene Fragen im Zusammenhang mit Deep Learning schauen. Die Studierenden werden so in die Lage versetzt, sich sowohl im weiteren Studienverlauf als auch im Berufsleben kompetent mit Ansätzen zu beschäftigen, die auf Deep Learning beruhen.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Module Contents</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Deep learning algorithms and their application for object recognition in images.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Lab</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <ul style="list-style-type: none"> <li>training of a neural network</li> <li>evaluation of the performance of a neural network</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Teaching and Learning Methods</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <ul style="list-style-type: none"> <li>Lecture</li> <li>Lab</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Examination Types with Weights</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <ul style="list-style-type: none"> <li>accompanying: exercise lab [ungraded] and</li> <li>final: (digital) written exam or oral examination or single/multiple choice [100%]</li> </ul>                                                                                                                                                                                                                                                                                                                                     |
| <b>Workload</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 150 Hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Contact Hours</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 34 Hours $\triangleq$ 3 SWS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Self-Study</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 116 Hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Recommended Prerequisites</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | The students should have some basic knowledge about image processing and pattern recognition                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Mandatory Prerequisites</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Lab requires attendance in the amount of: 4 Termine                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Recommended Literature</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | <ul style="list-style-type: none"> <li>I. Goodfellow, Y. Bengio und A. Courville. Deep Learning. MIT Press, 2016</li> <li>C. C. Aggarwal. Neural Networks and Deep Learning: A Textbook. Springer, 2018</li> <li>C. Bishop und H. Bishop. Deep Learning: Foundations and Concepts. Springer, 2024</li> <li>D. V. Godoy. Deep Learning with PyTorch Step-by-Step: A Beginner's Guide. Fundamentals. 2022</li> <li>D. V. Godoy. Deep Learning with PyTorch Step-by-Step: A Beginner's Guide. Computer Vision. 2022</li> </ul> |

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| <b>Included in Elective Catalog</b> | WM - Allgemeiner Wahlmodulbereich |
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| <b>Included in Specialization</b> |  |
|-----------------------------------|--|

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| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"> <li>▪ DLO in Master Communication Systems and Networks PO3</li> <li>▪ DLO in Master Communication Systems and Networks PO4</li> <li>▪ DLO in Master Elektrotechnik PO3</li> <li>▪ DLO in Master Medientechnologie PO3</li> <li>▪ DLO in Master Medientechnologie PO4</li> <li>▪ DLO in Master Technische Informatik PO3</li> <li>▪ DLO in Master Informatik und Systems-Engineering PO1</li> </ul> |
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| <b>Specifics and Notes</b> |  |
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| <b>Last Update</b> | 19.7.2025, 14:32:16 |
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## 6.5 DMC - Digital Motion Control

|                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Module ID</b>                                                                                                                                                                                                                                                                                                                                         | DMC                                                                                                                                                         |
| <b>Module Name</b>                                                                                                                                                                                                                                                                                                                                       | Digital Motion Control                                                                                                                                      |
| <b>Type of Module</b>                                                                                                                                                                                                                                                                                                                                    | Elective Modules                                                                                                                                            |
| <b>Recognized Course</b>                                                                                                                                                                                                                                                                                                                                 | DMC - Digital Motion Control                                                                                                                                |
| <b>ECTS credits</b>                                                                                                                                                                                                                                                                                                                                      | 5                                                                                                                                                           |
| <b>Language</b>                                                                                                                                                                                                                                                                                                                                          | deutsch                                                                                                                                                     |
| <b>Duration of Module</b>                                                                                                                                                                                                                                                                                                                                | 1 Semester                                                                                                                                                  |
| <b>Recommended Semester</b>                                                                                                                                                                                                                                                                                                                              | 1-2                                                                                                                                                         |
| <b>Frequency of Course</b>                                                                                                                                                                                                                                                                                                                               | every summer term                                                                                                                                           |
| <b>Module Coordinator</b>                                                                                                                                                                                                                                                                                                                                | Prof. Dr. Jens Onno Krah/Professor Fakultät IME                                                                                                             |
| <b>Lecturer(s)</b>                                                                                                                                                                                                                                                                                                                                       | Prof. Dr. Jens Onno Krah/Professor Fakultät IME                                                                                                             |
| <b>Learning Outcome(s)</b>                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                             |
| <ul style="list-style-type: none"> <li>Servomotoren kennenlernen und betreiben</li> <li>Servoumrichter kennenlernen und verwenden</li> <li>Digitale Regelalgorithmen nutzen</li> <li>Prozessidentifikation und Parameterestimation</li> <li>Auslegung von Antriebssystemen</li> </ul>                                                                    |                                                                                                                                                             |
| <b>Module Contents</b>                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                             |
| <b>Lecture / Exercises</b>                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                             |
| <ul style="list-style-type: none"> <li>Structure of servo motors</li> <li>Structure of servo inverters</li> <li>Digital control algorithms</li> <li>Process identification</li> <li>Design of drive systems</li> </ul>                                                                                                                                   |                                                                                                                                                             |
| <b>Lab</b>                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                             |
| <ul style="list-style-type: none"> <li>Direct Digital Control</li> <li>Quasi-continuous control</li> <li>Predictor / Observer</li> <li>Parameterization of a control system</li> <li>Evaluation of Bode diagrams</li> <li>Demonstrate action competence</li> <li>Commissioning of a servocontroller</li> <li>Minimization of following errors</li> </ul> |                                                                                                                                                             |
| <b>Teaching and Learning Methods</b>                                                                                                                                                                                                                                                                                                                     | <ul style="list-style-type: none"> <li>Lecture / Exercises</li> <li>Lab</li> </ul>                                                                          |
| <b>Examination Types with Weights</b>                                                                                                                                                                                                                                                                                                                    | <ul style="list-style-type: none"> <li>accompanying: lab report [ungraded] and</li> <li>final: (digital) written exam or oral examination [100%]</li> </ul> |
| <b>Workload</b>                                                                                                                                                                                                                                                                                                                                          | 150 Hours                                                                                                                                                   |
| <b>Contact Hours</b>                                                                                                                                                                                                                                                                                                                                     | 45 Hours $\triangleq$ 4 SWS                                                                                                                                 |
| <b>Self-Study</b>                                                                                                                                                                                                                                                                                                                                        | 105 Hours                                                                                                                                                   |
| <b>Recommended Prerequisites</b>                                                                                                                                                                                                                                                                                                                         | RT, DSS                                                                                                                                                     |

|                                                  |                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Mandatory Prerequisites</b>                   | Lab requires attendance in the amount of: 3 Termine                                                                                                                                                                                                                                                                                                                                                        |
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"><li>▪ Krah, Jens Onno, Vorlesungsskript MC</li><li>▪ Krah, Jens Onno: Vorlesungsskript RT (Download)</li><li>▪ Handbuch ServoStar 300: <a href="http://www.danahermotion.net">www.danahermotion.net</a></li><li>▪ Schultz, G.: Regelungstechnik, Oldenbourg Verlag, München-Wien</li><li>▪ Lutz, Wendt: Taschenbuch der Regelungstechnik, Verlag Harri Deutsch</li></ul> |
| <b>Included in Elective Catalog</b>              | <ul style="list-style-type: none"><li>▪ SV - Studienschwerpunktmodule</li><li>▪ WM - Allgemeiner Wahlmodulbereich</li></ul>                                                                                                                                                                                                                                                                                |
| <b>Included in Specialization</b>                | AU - Automatisierungstechnik                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"><li>▪ DMC in Master Communication Systems and Networks PO3</li><li>▪ DMC in Master Communication Systems and Networks PO4</li><li>▪ DMC in Master Elektrotechnik PO3</li><li>▪ DMC in Master Technische Informatik PO3</li><li>▪ DMC in Master Informatik und Systems-Engineering PO1</li></ul>                                                                          |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Last Update</b>                               | 19.7.2025, 14:32:16                                                                                                                                                                                                                                                                                                                                                                                        |

## 6.6 DSP - Digital Signal Processing

|                             |                                                     |
|-----------------------------|-----------------------------------------------------|
| <b>Module ID</b>            | DSP                                                 |
| <b>Module Name</b>          | Digital Signal Processing                           |
| <b>Type of Module</b>       | Elective Modules                                    |
| <b>Recognized Course</b>    | DSP - Digital Signal Processing                     |
| <b>ECTS credits</b>         | 5                                                   |
| <b>Language</b>             | englisch                                            |
| <b>Duration of Module</b>   | 1 Semester                                          |
| <b>Recommended Semester</b> | 1-2                                                 |
| <b>Frequency of Course</b>  | every winter term                                   |
| <b>Module Coordinator</b>   | Prof. Dr. Harald Elders-Boll/Professor Fakultät IME |
| <b>Lecturer(s)</b>          | Prof. Dr. Harald Elders-Boll/Professor Fakultät IME |

### Learning Outcome(s)

Design, analyse and implement DSP systems in soft and hardware considering computational complexity and hardware resource limitation, by a thorough understanding of the theoretical concepts, especially frequency domain analysis, and practical implementation of DSP systems in software using Python and on microprocessors, to be able to design, select, use and apply actual and future DSP systems for various signal processing application in commercial products.

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**Module Contents****Lecture / Exercises**

Signals, Systems and Digital Signal Processing

Basic Elements of DSP Systems

Classification of Signals

Continuous-Time and Discrete-Time Signals

Deterministic and Random Signals

Even and Odd Signals

Periodic and Aperiodic Signals

Energy and Power of Signals

Some Fundamental Signals

Discrete-Time Linear Time-Invariant Systems

Difference Equations

Discrete-Time Convolution

Unit-Pulse and Impulse Response

Basic Systems Properties: Causality, Stability, Memory

Ideal Sampling and Reconstruction

Ideal Sampling and the Sampling Theorem

Aliasing

Fourier-Transform of Discrete-Time Signals

Eigenfunctions of Discrete-Time LTI Systems

Frequency response of Discrete-Time LTI Systems

The Fourier-Transform of Discrete-Time Signals

Ideal Continuous-Time Filters

Discrete Fourier-Transform

Sampling the DTFT

The DFT and the Inverse DFT

The Fast Fourier Transform

Radix-2 FFT Algorithms

Linear Convolution Using the FFT

Overlap-And-Add

Random Signals

Review of Probability and Random Variables

Ensemble Averages

Correlation Functions

Stationary and Ergodic Processes

Power Spectral Density

Transmission of Random Signals over LTI Systems

Advanced Sampling Techniques

Quantization and Encoding

Sampling of Bandpass Signals

Sampling of Random Signals

Sample Rate Conversion

Sample Rate Reduction by an Integer Factor

Sample Rate Increase by an Integer Factor

Sample Rate Conversion by a Rational Factor

Oversampling and Noise Shaping

Students understand the fundamentals of discrete-time signals and systems

Students can analyse the frequency content of a given signal using the appropriate Fourier-Transform and methods for spectrum estimation

Analysis of discrete-time LTI Systems

Students can calculate the output signal via convolution

Students can determine the frequency response of a given system

Students can characterize a given system in the frequency domain and in the z-domain

Implementation of discrete-time LTI systems  
 Students can implement the convolution sum in software  
 Students can implement different structures for IIR systems in software  
 Students can use the FFT to implement an FIR system

### Lab

Review of Probability and Random Variables  
 Moments, Averages and Distribution Functions  
 Random Signals  
 Ensemble Averages  
 Correlation Functions  
 Stationary and Ergodic Processes  
 Power Spectral Density  
 Transmission of Random Signals over LTI Systems  
 Combatting noise  
 Remove or suppress high-frequency noise from low-pass signals  
 Ability to trade-off different methods for digital coding of speech and audio signals

**Teaching and Learning Methods**

- Lecture / Exercises
- Lab

**Examination Types with Weights**

- accompanying: (intermediate) certificate [ungraded] and
- final: oral examination [100%]

**Workload** 150 Hours

**Contact Hours** 45 Hours  $\triangleq$  4 SWS

**Self-Study** 105 Hours

**Recommended Prerequisites**

No formal requirements, but students will be expected to be familiar with:  
 Basic Knowledge of Signals and Systems: Continuous-Time LTI-Systems and Convolution, Fourier-Transform  
 Basic Knowledge of Probability and Random Variables

**Mandatory Prerequisites**

- Lab requires attendance in the amount of: 8 Termine
- Participation in final examination only after successful participation in Lab

**Recommended Literature**

- John G. Proakis and Dimitris K. Manolakis. Digital Signal Processing (4th Edition). Prentice Hall, 2006.
- Alan V. Oppenheim, Ronald W. Schaffer. Discrete-Time Signal Processing (3rd Edition). Prentice Hall, 2007.
- Vinay Ingle and John Proakis. Digital Signal Processing using MATLAB. Cengage Learning Engineering, 2011.

**Included in Elective Catalog** WM - Allgemeiner Wahlmodulbereich

**Included in Specialization**

**Use of the Module in Other Study Programs**

- DSP in Master Communication Systems and Networks PO3
- DSP in Master Communication Systems and Networks PO4
- DSP in Master Technische Informatik PO3
- DSP in Master Informatik und Systems-Engineering PO1

### Specifics and Notes

**Last Update** 19.7.2025, 14:32:16

## 6.7 EBA - Elektrische Bahnen

|                             |                                                 |
|-----------------------------|-------------------------------------------------|
| <b>Module ID</b>            | EBA                                             |
| <b>Module Name</b>          | Elektrische Bahnen                              |
| <b>Type of Module</b>       | Elective Modules                                |
| <b>Recognized Course</b>    | EBA - Electric Railways                         |
| <b>ECTS credits</b>         | 5                                               |
| <b>Language</b>             | deutsch                                         |
| <b>Duration of Module</b>   | 1 Semester                                      |
| <b>Recommended Semester</b> | 1-2                                             |
| <b>Frequency of Course</b>  | every winter term                               |
| <b>Module Coordinator</b>   | Prof. Dr. Wolfgang Evers/Professor Fakultät IME |
| <b>Lecturer(s)</b>          | Prof. Dr. Wolfgang Evers/Professor Fakultät IME |

### Learning Outcome(s)

Die Studierenden können Systeme der elektrischen Schienenbahnen analysieren und einen interdisziplinären Kontext herstellen, indem sie die für die jeweilige Problemstellung geeigneten Zusammenhänge kombinieren und so zu Lösungen kommen, um später Elektroausrüstungen für Schienenfahrzeuge und Schieneninfrastruktur zu entwickeln, zu projektieren oder zu betreiben.

### Module Contents

#### Lecture / Exercises

- Railway vehicles with commutator motors
- \* DC railways
- \* Alternating current railways
- Railway vehicles with three-phase motors
- \* Asynchronous machine
- \* Power converter for the asynchronous machine
- \* Synchronous machine
- Linear drives
- Magnetic levitation systems
- \* Static-catching levitation
- \* Dynamic-repulsive hovering
- \* Static-repulsive hovering
- Executed and projected magnetic levitation trains
- \* Transrapid
- \* MagLev system
- Discuss and evaluate the advantages and disadvantages of different systems (power systems, wheel / rail vs. magnetic levitation)
- Classification of electrotechnical solutions in interdisciplinary concepts

#### Lab

Working out various aspects of railway operation using computer simulations

|                                      |                                                                                        |
|--------------------------------------|----------------------------------------------------------------------------------------|
| <b>Teaching and Learning Methods</b> | <ul style="list-style-type: none"> <li>▪ Lecture / Exercises</li> <li>▪ Lab</li> </ul> |
|--------------------------------------|----------------------------------------------------------------------------------------|

|                                       |                                                                                                                                       |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| <b>Examination Types with Weights</b> | <ul style="list-style-type: none"> <li>▪ accompanying: lab report [ungraded] and</li> <li>▪ final: oral examination [100%]</li> </ul> |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|

|                 |           |
|-----------------|-----------|
| <b>Workload</b> | 150 Hours |
|-----------------|-----------|

|                      |                      |
|----------------------|----------------------|
| <b>Contact Hours</b> | 45 Hours $\pm$ 4 SWS |
|----------------------|----------------------|

|                   |           |
|-------------------|-----------|
| <b>Self-Study</b> | 105 Hours |
|-------------------|-----------|

|                                                  |                                                                                                                                                                                                                  |
|--------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Prerequisites</b>                 | Fundamentals of electrical engineering, electronics and mechanics<br>Basic understanding of electrical machines                                                                                                  |
| <b>Mandatory Prerequisites</b>                   | <ul style="list-style-type: none"><li>▪ Lab requires attendance in the amount of: 2 Termine</li><li>▪ Participation in final examination only after successful participation in Lab</li></ul>                    |
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"><li>▪ Zarko Filipovic, Elektrische Bahnen Springer Verlag, 1989, ISBN 3-540-55093-3</li></ul>                                                                                  |
| <b>Included in Elective Catalog</b>              | WM - Allgemeiner Wahlmodulbereich                                                                                                                                                                                |
| <b>Included in Specialization</b>                |                                                                                                                                                                                                                  |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"><li>▪ EBA in Master Communication Systems and Networks PO3</li><li>▪ EBA in Master Communication Systems and Networks PO4</li><li>▪ EBA in Master Elektrotechnik PO3</li></ul> |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                  |
| <b>Last Update</b>                               | 19.7.2025, 14:32:16                                                                                                                                                                                              |

## 6.8 EFA - Elektrische Fahrzeugantriebe

|                             |                                                 |
|-----------------------------|-------------------------------------------------|
| <b>Module ID</b>            | EFA                                             |
| <b>Module Name</b>          | Elektrische Fahrzeugantriebe                    |
| <b>Type of Module</b>       | Elective Modules                                |
| <b>Recognized Course</b>    | EFA - Electric vehicle drivetrain               |
| <b>ECTS credits</b>         | 5                                               |
| <b>Language</b>             | deutsch                                         |
| <b>Duration of Module</b>   | 1 Semester                                      |
| <b>Recommended Semester</b> | 1-2                                             |
| <b>Frequency of Course</b>  | every summer term                               |
| <b>Module Coordinator</b>   | Prof. Dr. Andreas Lohner/Professor Fakultät IME |
| <b>Lecturer(s)</b>          | Prof. Dr. Andreas Lohner/Professor Fakultät IME |

### Learning Outcome(s)

Die Studierenden lernen den Aufbau moderner, elektrischer und hybrider Fahrzeugantriebe kennen und sie erstellen die wesentlichen Steuerungs- und Regelungskonzepte der unterschiedlichen Antriebsmaschinen, indem sie Modelle der Maschinen, der Leistungselektronik und der Regelung mit dem Tool Matlab/Simulink modellieren und simulieren, um für verschiedene Anwendungen spezifische Antriebe auswählen, parametrieren und in Betrieb nehmen zu können und um weiterführend auch neue Regelungsverfahren entwickeln zu können.

---



**Module Contents****Lecture / Exercises**

Basic concepts and historical drive development  
 Mechanical fundamentals, rotating field theory, modeling  
 Field-oriented control of the induction / synchronous machine  
 Structure, function and control of the switched reluctance machine  
 Further vehicle-specific controls  
 Electric train and bus drives with project examples  
 Hybrid and electric drive topologies with project examples  
 Storage technologies for vehicles

Students will be able to capture the functionalities of a modern vehicle propulsion system (hybrid and electric vehicle).  
 They know and understand the essential control concepts of the different topologies and are able to carry out simple closed-loop control simulations and to use this knowledge to convert the results to the drive.  
 Students are able to design and dimension drive systems.

**Lab**

Recognize drive characteristics and properties and record them by measurement (analyze drive system)

Structure the system  
 Define subsystems  
 Define subsystem functions  
 Create drivetrain model  
 Design drive control  
 Design energy management algorithms  
 Understand commercial development tools and use them purposefully  
 Put control on the target system into operation

Coping with complex tasks in a team  
 Plan and control simple projects  
 Comply with agreements and deadlines  
 Plan and conduct reviews

The students learn methods for the dynamic description and regulation of hybrid and electric vehicle drives and thereby obtain decision-making authority.

The students have experience in dealing with power electronics, drives, classic measuring devices and are able to model drivetrains with a simulation tool.

Students have the ability to understand, dimension and control electric and hybrid drivetrains.

|                              |                       |
|------------------------------|-----------------------|
| <b>Teaching and Learning</b> | ▪ Lecture / Exercises |
| <b>Methods</b>               | ▪ Lab                 |

|                                       |                                                                               |
|---------------------------------------|-------------------------------------------------------------------------------|
| <b>Examination Types with Weights</b> | ▪ accompanying: lab report [ungraded] and<br>▪ final: oral examination [100%] |
|---------------------------------------|-------------------------------------------------------------------------------|

|                 |           |
|-----------------|-----------|
| <b>Workload</b> | 150 Hours |
|-----------------|-----------|

|                      |                      |
|----------------------|----------------------|
| <b>Contact Hours</b> | 45 Hours $\pm$ 4 SWS |
|----------------------|----------------------|

|                   |           |
|-------------------|-----------|
| <b>Self-Study</b> | 105 Hours |
|-------------------|-----------|

|                                  |                                                                                                                          |
|----------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Prerequisites</b> | Fundamentals of electrical engineering<br>power electronics<br>Basics of electric drives<br>Analogue signals and systems |
|----------------------------------|--------------------------------------------------------------------------------------------------------------------------|

|                                |                                                    |
|--------------------------------|----------------------------------------------------|
| <b>Mandatory Prerequisites</b> | Lab requires attendance in the amount of: 1 Termin |
|--------------------------------|----------------------------------------------------|

|                               |                                                                                                                                                                                                                                                                                                                                    |
|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Literature</b> | <ul style="list-style-type: none"> <li>■ Leonhard, W.: Regelung Elektrischer Antriebe, Springer Verlag</li> <li>■ Wellenreuter, G.: Automatisieren mit SPS, Vieweg Verlag</li> <li>■ Böker, J.: Geregelte Drehstromantriebe, Uni Paderborn</li> <li>■ Gerling, D.: Elektrische Maschinen und Antriebe, B.W.-Uni München</li> </ul> |
|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                     |                                   |
|-------------------------------------|-----------------------------------|
| <b>Included in Elective Catalog</b> | WM - Allgemeiner Wahlmodulbereich |
|-------------------------------------|-----------------------------------|

**Included in Specialization**

|                                                  |                                  |
|--------------------------------------------------|----------------------------------|
| <b>Use of the Module in Other Study Programs</b> | EFA in Master Elektrotechnik PO3 |
|--------------------------------------------------|----------------------------------|

**Specifics and Notes**

|                    |                     |
|--------------------|---------------------|
| <b>Last Update</b> | 19.7.2025, 14:32:16 |
|--------------------|---------------------|

## 6.9 EMM - Energiemanagement in Energieverbundsystemen

|                             |                                                   |
|-----------------------------|---------------------------------------------------|
| <b>Module ID</b>            | EMM                                               |
| <b>Module Name</b>          | Energiemanagement in Energieverbundsystemen       |
| <b>Type of Module</b>       | Elective Modules                                  |
| <b>Recognized Course</b>    | EMM - Energy Management in Interconnected Systems |
| <b>ECTS credits</b>         | 5                                                 |
| <b>Language</b>             | deutsch                                           |
| <b>Duration of Module</b>   | 1 Semester                                        |
| <b>Recommended Semester</b> | 1-2                                               |
| <b>Frequency of Course</b>  | every winter term                                 |
| <b>Module Coordinator</b>   | Prof. Dr. Ingo Stadler/Professor Fakultät IME     |
| <b>Lecturer(s)</b>          | Prof. Dr. Ingo Stadler/Professor Fakultät IME     |

### Learning Outcome(s)

Die Studierenden analysieren die Mechanismen und Voraussetzungen zur Garantie der Stabilität von elektrischen Verbundsystemen, indem sie die Frequenz- und Spannungsstabilität beeinflussenden Kriterien kennen, um später neue Maßnahmen in einem geänderten, auf erneuerbaren Energien basierenden Energiesystem zur Gewährleistung der Stabilität entwickeln zu können.

Die Studierenden analysieren die Regelmechanismen heutiger Verbundsysteme, indem Sie die Begrifflichkeiten, die Wirkungsweise und die Organisation verschiedener Stufen der Regelleistung und Regelenergie verstehen, um zukünftige Maßnahmen und Alternativen zu deren Bereitstellung einschätzen und selbst entwickeln können.

Die Studierenden kennen Möglichkeiten zur Sektorenkopplung und können deren Einsatz zum Demand Response bewerten, indem Sie Differentialgleichungen zur Lösung von Bilanzproblemen erstellen und lösen können, numerischer Verfahren zur Lösung nicht stationärer Veränderungen in Speichersystemen erstellen und anwenden können, um damit Lösungen in verschiedenen Zeit- und Leistungsbereichen des Demand Response zu beurteilen.

Die Studierenden kennen und sind in der Lage, Technologien der Energiespeicherung in verschiedensten Zeit-, Energie- und Leistungsbereichen zu beurteilen, indem sie die relevanten Charakteristiken und Ökonomien kennen, um deren Einsatz für unterschiedliche Anwendungen beurteilen zu können.

Die Studierenden sind in der Lage, die verschiedensten Möglichkeiten zur Herstellung der Blindleistungsbilanz in Verbundsystemen benennen und zu analysieren, indem sie die Leitungsgleichungen zur Netzanalyse anwenden, um mit verschiedenen Maßnahmen die Spannungsqualität gewährleisten zu können.

### Module Contents

#### Lecture

The students analyse the mechanisms and prerequisites for guaranteeing the stability of interconnected electrical systems by knowing the criteria influencing frequency and voltage stability in order to later be able to develop new measures in a changed energy system based on renewable energies to guarantee stability.

The students analyse the control mechanisms of today's interconnected systems by understanding the terminology, the mode of operation and the organisation of different levels of control power and control energy in order to be able to assess future measures and alternatives for their provision and develop them themselves.

The students know possibilities for sector coupling and can evaluate their use for demand response by creating and solving differential equations for solving balance problems, creating and applying numerical methods for solving non-stationary changes in storage systems in order to evaluate solutions in different time and power ranges of demand response.

Students will know and be able to evaluate energy storage technologies in a wide range of time, energy and power domains by knowing the relevant characteristics and economics to assess their use for different applications.

The students are able to name and analyse the various possibilities for establishing the reactive power balance in interconnected systems by applying the line equations for network analysis in order to be able to guarantee the voltage quality with various measures.

#### Project

Changing current projects are worked on.

|                                                  |                                                                                                                                                                                                                  |
|--------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Teaching and Learning Methods</b>             | <ul style="list-style-type: none"><li>▪ Lecture</li><li>▪ Project</li></ul>                                                                                                                                      |
| <b>Examination Types with Weights</b>            | <ul style="list-style-type: none"><li>▪ accompanying: project work [50%] and</li><li>▪ final: (digital) written exam [50%]</li></ul>                                                                             |
| <b>Workload</b>                                  | 150 Hours                                                                                                                                                                                                        |
| <b>Contact Hours</b>                             | 34 Hours $\pm$ 3 SWS                                                                                                                                                                                             |
| <b>Self-Study</b>                                | 116 Hours                                                                                                                                                                                                        |
| <b>Recommended Prerequisites</b>                 | None                                                                                                                                                                                                             |
| <b>Mandatory Prerequisites</b>                   | Project requires attendance in the amount of: 3 Termine                                                                                                                                                          |
| <b>Recommended Literature</b>                    |                                                                                                                                                                                                                  |
| <b>Included in Elective Catalog</b>              | <ul style="list-style-type: none"><li>▪ SV - Studienschwerpunktmodule</li><li>▪ WM - Allgemeiner Wahlmodulbereich</li></ul>                                                                                      |
| <b>Included in Specialization</b>                | ET - Elektrische Energietechnik                                                                                                                                                                                  |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"><li>▪ EMM in Master Communication Systems and Networks PO3</li><li>▪ EMM in Master Communication Systems and Networks PO4</li><li>▪ EMM in Master Elektrotechnik PO3</li></ul> |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                  |
| <b>Last Update</b>                               | 19.7.2025, 14:32:16                                                                                                                                                                                              |

**6.10 ERMK - Entrepreneurship, Gewerblicher Rechtsschutz, Market Knowledge**

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
| <b>Module ID</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | ERMK                                                                                       |
| <b>Module Name</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Entrepreneurship, Gewerblicher Rechtsschutz, Market Knowledge                              |
| <b>Type of Module</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Elective Modules                                                                           |
| <b>Recognized Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | GER - Industrial property protection                                                       |
| <b>ECTS credits</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 5                                                                                          |
| <b>Language</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | deutsch                                                                                    |
| <b>Duration of Module</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 1 Semester                                                                                 |
| <b>Recommended Semester</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 1-2                                                                                        |
| <b>Frequency of Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | every term                                                                                 |
| <b>Module Coordinator</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Prof. Dr. Holger Weigand/Professor Fakultät IME                                            |
| <b>Lecturer(s)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Ladrière                                                                                   |
| <b>Learning Outcome(s)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                            |
| Befähigung zum unternehmerischen Denken<br>Einschätzung des Innovationspotentials neuer technischer Entwicklungen<br>Verständnis der Mechanismen des Marktes im Hinblick auf neue technische Innovationen                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                            |
| <b>Module Contents</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                            |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                            |
| Types of industrial property rights, significance for companies and inventors, significance of employee invention law and inventor personality law, prerequisites for protection, term of industrial property rights, structure of an application, life cycle from application to patent, subsequent applications, examination and opposition procedures, national, European and international applications, utility models, trademarks, design, law on the protection of secrets, professional field of patent engineer.<br><br>Carry out a patent search; determine the relevant type of protective right for a given case; be able to correctly file an application with regard to its formal structure; weigh up the advantages and disadvantages of national, European and international applications in a specific application; check the validity of a patent; develop a basic IP strategy. |                                                                                            |
| <b>Seminar</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                            |
| Types of industrial property rights, significance for companies and inventors, significance of employee invention law and inventor personality law, prerequisites for protection, term of industrial property rights, structure of an application, life cycle from application to patent, subsequent applications, examination and opposition procedures, national, European and international applications, utility models, trademarks, design, law on the protection of secrets, professional field of patent engineer.<br><br>Carry out a patent search; determine the relevant type of protective right for a given case; be able to correctly file an application with regard to its formal structure; weigh up the advantages and disadvantages of national, European and international applications in a specific application; check the validity of a patent; develop a basic IP strategy. |                                                                                            |
| <b>Teaching and Learning Methods</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <ul style="list-style-type: none"> <li>▪ Lecture</li> <li>▪ Seminar</li> </ul>             |
| <b>Examination Types with Weights</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <ul style="list-style-type: none"> <li>▪ accompanying: oral contribution [100%]</li> </ul> |
| <b>Workload</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 150 Hours                                                                                  |
| <b>Contact Hours</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 34 Hours $\pm$ 3 SWS                                                                       |
| <b>Self-Study</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 116 Hours                                                                                  |
| <b>Recommended Prerequisites</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                            |

**Mandatory  
Prerequisites**

**Recommended  
Literature**

**Included in Elective  
Catalog** WM - Allgemeiner Wahlmodulbereich

**Included in  
Specialization**

**Use of the Module in  
Other Study Programs**

- ERMK in Master Elektrotechnik PO3
- ERMK in Master Medientechnologie PO4
- ERMK in Master Technische Informatik PO3
- XIM in Master Technische Informatik PO3
- ERMK in Master Informatik und Systems-Engineering PO1

**Specifics and Notes**

**Last Update** 19.7.2025, 14:32:16

## 6.11 ESD - Embedded Systems Design

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Module ID</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | ESD                                                                                                                                                                                            |
| <b>Module Name</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Embedded Systems Design                                                                                                                                                                        |
| <b>Type of Module</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Elective Modules                                                                                                                                                                               |
| <b>Recognized Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | ESD - Embedded Systems Design                                                                                                                                                                  |
| <b>ECTS credits</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 5                                                                                                                                                                                              |
| <b>Language</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | deutsch, englisch bei Bedarf                                                                                                                                                                   |
| <b>Duration of Module</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 1 Semester                                                                                                                                                                                     |
| <b>Recommended Semester</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1-2                                                                                                                                                                                            |
| <b>Frequency of Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | every summer term                                                                                                                                                                              |
| <b>Module Coordinator</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Prof. Dr. Markus Cremer/Professor Fakultät IME                                                                                                                                                 |
| <b>Lecturer(s)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Prof. Dr. Markus Cremer/Professor Fakultät IME                                                                                                                                                 |
| <b>Learning Outcome(s)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                |
| <p>Die Studierenden können die Machbarkeit der Entwicklung einer Produktidee im Bereich der Embedded Systems in Bezug auf praktische Realisierbarkeit, Aufwand, Zeit und Kosten und mit vorausschauendem Blick auf den gesamten Entwicklungsprozess sicher beurteilen. Hierzu setzen sie, ausgehend von einer eigenen Produktidee, Methoden und Hilfsmittel (z.B. Software-Tools, Konzepte, Best-Practices, v.a. auch Hardwareentwicklung) eines typischen industriellen Entwicklungsprozesses für Embedded Systems eigenständig praktisch um. Später sind die Studierenden in der Lage, diesen gesamten Entwicklungsprozess in der Industrie oder in Forschungsprojekten autonom zu bewerten und umzusetzen.</p> |                                                                                                                                                                                                |
| <b>Module Contents</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                |
| <b>Lecture / Exercises</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                |
| <p>The exact content will not be determined until the summer semester 2025.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                |
| <b>Project</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                |
| <b>Teaching and Learning Methods</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <ul style="list-style-type: none"> <li>▪ Lecture / Exercises</li> <li>▪ Project</li> </ul>                                                                                                     |
| <b>Examination Types with Weights</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <ul style="list-style-type: none"> <li>▪ accompanying: project work [100%]</li> </ul>                                                                                                          |
| <b>Workload</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 150 Hours                                                                                                                                                                                      |
| <b>Contact Hours</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 45 Hours $\triangleq$ 4 SWS                                                                                                                                                                    |
| <b>Self-Study</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 105 Hours                                                                                                                                                                                      |
| <b>Recommended Prerequisites</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <p>Basic knowledge of electrical engineering (simple analog and digital circuits)</p> <p>Basic knowledge of embedded systems (basics of microcontrollers incl. implementation of firmware)</p> |
| <b>Mandatory Prerequisites</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                |

|                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"> <li>▪ Murti, K. (2022). Design Principles for Embedded Systems. Springer Singapore. <a href="https://doi.org/10.1007/978-981-16-3293-8">https://doi.org/10.1007/978-981-16-3293-8</a></li> <li>▪ Schmidt, R., Hauschild, D., &amp; Kluge, I. (2024). Elektronik Design: Theorie und Praxis. Elektronik Design: Theorie Und Praxis. <a href="https://doi.org/10.1007/978-3-662-68676-8">https://doi.org/10.1007/978-3-662-68676-8</a></li> <li>▪ Ünsalan, C., Gürhan, H. D., &amp; Yücel, M. E. (2022). Embedded system design with ARM Cortex-M microcontrollers: Applications with C, C++ and MicroPython. Embedded System Design with ARM Cortex-M Microcontrollers: Applications with C, C++ and MicroPython, 1–569. <a href="https://doi.org/10.1007/978-3-030-88439-0">https://doi.org/10.1007/978-3-030-88439-0</a></li> <li>▪ Morshed, B. I. (2021). Embedded systems - A hardware-software co-design approach: Unleash the power of arduino! In Embedded Systems - A Hardware-Software Co-Design Approach: Unleash the Power of Arduino! Springer International Publishing. <a href="https://doi.org/10.1007/978-3-030-66808-2">https://doi.org/10.1007/978-3-030-66808-2</a></li> <li>▪ Marwedel, P. (2021). Embedded System Design. <a href="https://doi.org/10.1007/978-3-030-60910-8">https://doi.org/10.1007/978-3-030-60910-8</a></li> <li>▪ Lienig, J., &amp; Scheible, J. (2020). Fundamentals of Layout Design for Electronic Circuits. Fundamentals of Layout Design for Electronic Circuits. <a href="https://doi.org/10.1007/978-3-030-39284-0">https://doi.org/10.1007/978-3-030-39284-0</a></li> </ul> |
| <b>Included in Elective Catalog</b>              | WM - Allgemeiner Wahlmodulbereich                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Included in Specialization</b>                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"> <li>▪ ESD in Master Communication Systems and Networks PO4</li> <li>▪ ESD in Master Medientechnologie PO4</li> <li>▪ ESD in Master Technische Informatik PO3</li> <li>▪ ESD in Master Informatik und Systems-Engineering PO1</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Permanent Links to Organization</b>           | <a href="#"><u>ILU course</u></a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Last Update</b>                               | 19.7.2025, 14:32:16                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |



## 6.12 FS - Forschungsseminar

|                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Module ID</b>                                                                                                                                                                                                                                                                                                                                                                                                                                          | FS                                                                                                                                                                                                                                                                                                                                                    |
| <b>Module Name</b>                                                                                                                                                                                                                                                                                                                                                                                                                                        | Forschungsseminar                                                                                                                                                                                                                                                                                                                                     |
| <b>Type of Module</b>                                                                                                                                                                                                                                                                                                                                                                                                                                     | Mandatory Module                                                                                                                                                                                                                                                                                                                                      |
| <b>Recognized Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                  | FS - Research Seminar                                                                                                                                                                                                                                                                                                                                 |
| <b>ECTS credits</b>                                                                                                                                                                                                                                                                                                                                                                                                                                       | 10                                                                                                                                                                                                                                                                                                                                                    |
| <b>Language</b>                                                                                                                                                                                                                                                                                                                                                                                                                                           | deutsch, englisch bei Bedarf                                                                                                                                                                                                                                                                                                                          |
| <b>Duration of Module</b>                                                                                                                                                                                                                                                                                                                                                                                                                                 | 1 Semester                                                                                                                                                                                                                                                                                                                                            |
| <b>Recommended Semester</b>                                                                                                                                                                                                                                                                                                                                                                                                                               | 2                                                                                                                                                                                                                                                                                                                                                     |
| <b>Frequency of Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                | every term                                                                                                                                                                                                                                                                                                                                            |
| <b>Module Coordinator</b>                                                                                                                                                                                                                                                                                                                                                                                                                                 | Prof. Dr. Jens Onno Krah/Professor Fakultät IME                                                                                                                                                                                                                                                                                                       |
| <b>Lecturer(s)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                        | verschiedene Dozenten*innen / diverse lecturers                                                                                                                                                                                                                                                                                                       |
| <b>Learning Outcome(s)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                       |
| <b>Module Contents</b>                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                       |
| <b>Seminar</b>                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                       |
| <p>In the seminar and at the poster presentation the student presents and defends his work. The discussion and discourse in the subject as a skill of the candidate is thus achieved.</p> <p>Independent research on the scientific question leads to a high increase in knowledge, also to the right and left of the actual core question.</p> <p>In the seminar and on the poster presentation the student learns about other scientific questions.</p> |                                                                                                                                                                                                                                                                                                                                                       |
| <b>Teaching and Learning Methods</b>                                                                                                                                                                                                                                                                                                                                                                                                                      | Seminar                                                                                                                                                                                                                                                                                                                                               |
| <b>Examination Types with Weights</b>                                                                                                                                                                                                                                                                                                                                                                                                                     | <ul style="list-style-type: none"> <li>■ accompanying: term paper or oral contribution [100%]</li> </ul>                                                                                                                                                                                                                                              |
| <b>Workload</b>                                                                                                                                                                                                                                                                                                                                                                                                                                           | 300 Hours                                                                                                                                                                                                                                                                                                                                             |
| <b>Contact Hours</b>                                                                                                                                                                                                                                                                                                                                                                                                                                      | 12 Hours $\pm$ 1 SWS                                                                                                                                                                                                                                                                                                                                  |
| <b>Self-Study</b>                                                                                                                                                                                                                                                                                                                                                                                                                                         | 288 Hours                                                                                                                                                                                                                                                                                                                                             |
| <b>Recommended Prerequisites</b>                                                                                                                                                                                                                                                                                                                                                                                                                          | Since the professional orientation of the seminar takes place in coordination with the supervising lecturer, the competence "scientific working" is rather to be brought along as a prerequisite, which is already trained in Bachelor's thesis. A further prerequisite is that the student is able to become familiar with the topics independently. |
| <b>Mandatory Prerequisites</b>                                                                                                                                                                                                                                                                                                                                                                                                                            | Seminar requires attendance in the amount of: 4 Präsentationen und 1 Posterausstellung                                                                                                                                                                                                                                                                |
| <b>Recommended Literature</b>                                                                                                                                                                                                                                                                                                                                                                                                                             | <ul style="list-style-type: none"> <li>■ die empfohlene Literatur hängt vom bearbeiteten Forschungsthema ab</li> </ul>                                                                                                                                                                                                                                |
| <b>Included in Elective Catalog</b>                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                       |
| <b>Included in Specialization</b>                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                       |
| <b>Use of the Module in Other Study Programs</b>                                                                                                                                                                                                                                                                                                                                                                                                          | FS in Master Elektrotechnik PO3                                                                                                                                                                                                                                                                                                                       |
| <b>Specifics and Notes</b>                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                       |
| <b>Last Update</b>                                                                                                                                                                                                                                                                                                                                                                                                                                        | 19.7.2025, 14:32:16                                                                                                                                                                                                                                                                                                                                   |

### 6.13 HIM - Advanced Mathematics

|                             |                                                                                                                                                                                                                        |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Module ID</b>            | HIM                                                                                                                                                                                                                    |
| <b>Module Name</b>          | Advanced Mathematics                                                                                                                                                                                                   |
| <b>Type of Module</b>       | Mandatory Module                                                                                                                                                                                                       |
| <b>Recognized Course</b>    | HIM - Advanced Mathematics                                                                                                                                                                                             |
| <b>ECTS credits</b>         | 5                                                                                                                                                                                                                      |
| <b>Language</b>             | deutsch und englisch                                                                                                                                                                                                   |
| <b>Duration of Module</b>   | 1 Semester                                                                                                                                                                                                             |
| <b>Recommended Semester</b> | 1                                                                                                                                                                                                                      |
| <b>Frequency of Course</b>  | every term                                                                                                                                                                                                             |
| <b>Module Coordinator</b>   | Prof. Dr. Heiko Knospe/Professor Fakultät IME                                                                                                                                                                          |
| <b>Lecturer(s)</b>          | <ul style="list-style-type: none"> <li>▪ Prof. Dr. Heiko Knospe/Professor Fakultät IME</li> <li>▪ Prof. Dr. Hubert Randerath/Professor Fakultät IME</li> <li>▪ Prof. Dr. Beate Rhein/Professor Fakultät IME</li> </ul> |

#### Learning Outcome(s)

Was: Das Modul vermittelt grundlegende Konzepte und Methoden der Mathematik, die in den Ingenieurwissenschaften benötigt werden (K. 8). Die Abstraktion und mathematischen Formalisierung von Problemen soll erlernt und angewendet werden (K. 2). Die Studierenden lernen die Anwendung mathematischer Methoden (K. 16). Es soll die Anwendung statistischer Verfahren und die Begründung wissenschaftlicher Aussagen erlernt werden (K. 17).

Womit: Der Dozent/die Dozentin vermittelt Wissen und Basisfertigkeiten in der Vorlesung. In der Übung bearbeiten die Studierenden unter Anleitung Aufgaben. Die Übung wird durch Hausaufgaben und Online-Aufgaben (E-Learning) ergänzt.

Wozu: Fortgeschrittene Mathematik-Kenntnisse (beispielweise in Vektoranalysis, Statistik und Optimierung) werden in mehreren Modulen des Studiengangs benötigt. Mathematische Methoden sind essentiell für Ingenieure, die wissenschaftlich arbeiten und wissenschaftliche Erkenntnisse anwenden und erweitern (HF2).

**Module Contents****Lecture / Exercises**

A combination of:

- Vector Analysis
- Probability Theory, Statistics and Multivariate Statistics
- Stochastic processes
- Optimization

Vector Analysis

- Vector Spaces
- Scalar and Vector Functions
- Differential Operators
- Line Integrals
- Double Integrals
- Triple Integrals
- Change of Variables
- Surface Integrals
- Divergence Theorem
- Theorem of Stokes
- Maxwell Equations

Probability and Statistics

- Descriptive Statistics
- Two-dimensional Data
- Simple Linear Regression
- Probability Spaces
- Random Variables
- Expectation, Variance, Moments
- Jointly Distributed Random Variables
- Independent Random Variables
- Covariance
- Binomial Random Variable
- Poisson Random Variable
- Uniform Random Variable
- Normal Random Variable
- Chi-Square Distribution
- t-Distribution
- Central Limit Theorem
- Distributions of Sampling Statistics
- Confidence Intervals
- Hypothesis Testing
- t-Test, f-Test, Chi-Square Test
- Overview of various Tests

Multivariate Statistics

- Analysis of multidimensional data
- Multivariate Random Variables
- Matrix decompositions, Singular Value Decomposition (SVD)
- Factor analysis, Principal Component Analysis (PCA)
- Multiple Linear Regression

Stochastic Processes

- Discrete and continuous time processes
- Random walk
- Markov chain
- Poisson process
- Queuing theory

## Optimization

- Linear Programming
- Unconstrained Optimization: Gradient method, Newton's method, Trust Region method
- Constrained Optimization: Karush–Kuhn–Tucker (KKT) conditions, Lagrange multipliers, Penalty and Barrier functions
- Special optimization problems: Mixed Integer Nonlinear Programming, Nonlinear Stochastic Optimization

-

**Teaching and Learning** Lecture / Exercises**Methods**

**Examination Types with Weights** ■ final: (digital) written exam or oral examination [100%]

**Workload** 150 Hours

**Contact Hours** 34 Hours  $\pm$  3 SWS

**Self-Study** 116 Hours

**Recommended Prerequisites** Differential and integral calculus and linear algebra (Bachelor-level mathematics)

**Mandatory Prerequisites**

**Recommended Literature**

- K. Burg, H. Haf, F. Wille, A. Meister, Vektoranalysis - Höhere Mathematik für Ingenieure, Naturwissenschaftler und Mathematiker, Springer Vieweg
- E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons
- L. Papula, Mathematik für Ingenieure und Naturwissenschaftler Band 3, Springer Vieweg
- R. E. Walpole, R. H. Myers, S. L. Myers, K. Ye, Probability & Statistics for Engineers & Scientists, Prentice Hall
- S. M. Ross, Probability and Statistics for Engineers and Scientists, Elsevier
- S. M. Ross, Stochastic Processes, John Wiley & Sons
- U. Krengel, Einführung in die Wahrscheinlichkeitstheorie und Statistik
- A. Koop, H. Moock, Lineare Optimierung, Springer
- R. Reinhardt, A. Hoffmann, T. Gerlach, Nichtlineare Optimierung, Springer
- M. Ulbrich, S. Ulbrich, Nichtlineare Optimierung, Birkhäuser

**Included in Elective Catalog**

**Included in Specialization**

**Use of the Module in Other Study Programs**

- HIM in Master Communication Systems and Networks PO3
- HIM in Master Communication Systems and Networks PO4
- HIM in Master Elektrotechnik PO3
- HIM in Master Technische Informatik PO3
- HIM in Master Informatik und Systems-Engineering PO1

**Specifics and Notes**

**Last Update** 19.7.2025, 14:32:16

## 6.14 HSUT - Hochspannungsübertragungstechnik

|                             |                                                   |
|-----------------------------|---------------------------------------------------|
| <b>Module ID</b>            | HSUT                                              |
| <b>Module Name</b>          | Hochspannungsübertragungstechnik                  |
| <b>Type of Module</b>       | Elective Modules                                  |
| <b>Recognized Course</b>    | HSUT - High Voltage Transmission Technology       |
| <b>ECTS credits</b>         | 5                                                 |
| <b>Language</b>             | deutsch                                           |
| <b>Duration of Module</b>   | 1 Semester                                        |
| <b>Recommended Semester</b> | 1-2                                               |
| <b>Frequency of Course</b>  | every summer term                                 |
| <b>Module Coordinator</b>   | Prof. Dr. Christof Humpert/Professor Fakultät IME |
| <b>Lecturer(s)</b>          | Prof. Dr. Christof Humpert/Professor Fakultät IME |

### Learning Outcome(s)

Die Studierenden können Systeme und Betriebsmittel der Hochspannungsübertragungstechnik hinsichtlich technischer und betriebswirtschaftlicher Kriterien analysieren und auswählen, indem sie

- Anforderungen an Übertragungssysteme erkennen,
  - Spannungsbelastungen im Nenn- und Fehlerfall bestimmen und Maßnahmen zur Reduktion der Belastungen auslegen,
  - Vor- und Nachteile aktueller und zukünftiger Technologien analysieren und
  - vereinfachte Wirtschaftlichkeitsberechnungen durchführen,
- um später fundierte Entscheidungen hinsichtlich des optimalen Aus- und Umbaus der elektrischen Netze unter gesellschaftlichen und politischen Randbedingungen treffen zu können.

**Module Contents****Lecture / Exercises**

Overvoltages and insulation coordination

- Generation and categories of overvoltages
- Propagation of overvoltages
- Traveling waves
- Reflections
- Limitation of overvoltages
- Types of surge arresters
- Properties, structure and selection

Systems of high voltage transmission

- High-voltage AC transmission (HVAC)
- Optimal transmission voltage
- Structure and different types of switchgears, their properties and applications
- High-voltage DC transmission (HVDC)
- Advantages and disadvantages in comparison to HVAC
- Structure and operation of converter stations
- Cost comparison to HVAC systems
- HVDC grids

Equipment of high voltage transmission

- Circuit breakers
- Principle of operation
- Different Types and their applications
- Circuit breakers for HVDC
- Superconducting equipment (cables, current limiters)
- Principle of operation and applications
- Cooling technology
- Losses and costs

Determine the stresses of transmission systems

- Calculate operating voltages and overvoltages for a given voltage level
- Plan limitation of overvoltages
- Analyze and calculate traveling wave processes (refraction, reflection)
- Derive current carrying capacity and maximum losses

Determine business aspects

- Carry out investment cost comparison
- Perform operating cost comparison

---

**Project**

Deepening a specific problem in electrical engineering using a calculation example

Solve project task in the team

Compile the basics of a calculation software

Perform numerical calculations

Compare numerical results with analytical

Discuss results related to practical application

Summarize results in a report

---

**Lab**

Generation and measurement of AC, DC and impulse voltages

Propagation and limitation of overvoltages

Plan high voltage tests

Dimension high voltage test circuits

Determine test criteria for components of high voltage technology  
Summarize results in a report

|                                                  |                                                                                                                                                                                                                                                       |
|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Teaching and Learning Methods</b>             | <ul style="list-style-type: none"> <li>▪ Lecture / Exercises</li> <li>▪ Project</li> <li>▪ Lab</li> </ul>                                                                                                                                             |
| <b>Examination Types with Weights</b>            | <ul style="list-style-type: none"> <li>▪ accompanying: lab report [20%] and</li> <li>▪ accompanying: lab report [20%] and</li> <li>▪ final: oral examination [60%]</li> </ul>                                                                         |
| <b>Workload</b>                                  | 150 Hours                                                                                                                                                                                                                                             |
| <b>Contact Hours</b>                             | 57 Hours $\pm$ 5 SWS                                                                                                                                                                                                                                  |
| <b>Self-Study</b>                                | 93 Hours                                                                                                                                                                                                                                              |
| <b>Recommended Prerequisites</b>                 | Basics of electrical engineering and electronics<br>Basic understanding of electric fields in dielectrics                                                                                                                                             |
| <b>Mandatory Prerequisites</b>                   | <ul style="list-style-type: none"> <li>▪ Lab requires attendance in the amount of: 3 Termine</li> <li>▪ Participation in final examination only after successful participation in Lab</li> </ul>                                                      |
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"> <li>▪ Küchler, Andreas: Hochspannungstechnik: Grundlagen – Technologie – Anwendung (Springer)</li> <li>▪ Heuck, Klaus; Dettmann, Klaus-Dieter; Schulz, Detlef: Elektrische Energieversorgung (Springer)</li> </ul> |
| <b>Included in Elective Catalog</b>              | <ul style="list-style-type: none"> <li>▪ SV - Studienschwerpunktmodule</li> <li>▪ WM - Allgemeiner Wahlmodulbereich</li> </ul>                                                                                                                        |
| <b>Included in Specialization</b>                | ET - Elektrische Energietechnik                                                                                                                                                                                                                       |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"> <li>▪ HSUT in Master Communication Systems and Networks PO3</li> <li>▪ HSUT in Master Communication Systems and Networks PO4</li> <li>▪ HSUT in Master Elektrotechnik PO3</li> </ul>                               |
| <b>Permanent Links to Organization</b>           | <a href="#"><u>ILU course for High Voltage Transmission Technology</u></a>                                                                                                                                                                            |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                                                       |
| <b>Last Update</b>                               | 19.7.2025, 14:32:16                                                                                                                                                                                                                                   |

## 6.15 IBD - InnoBioDiv

|                             |                                              |
|-----------------------------|----------------------------------------------|
| <b>Module ID</b>            | IBD                                          |
| <b>Module Name</b>          | InnoBioDiv                                   |
| <b>Type of Module</b>       | Elective Modules                             |
| <b>Recognized Course</b>    | IBD - InnoBioDiv student projects            |
| <b>ECTS credits</b>         | 5                                            |
| <b>Language</b>             | englisch                                     |
| <b>Duration of Module</b>   | 0.5 Semester                                 |
| <b>Recommended Semester</b> | 1-2                                          |
| <b>Frequency of Course</b>  | every term                                   |
| <b>Module Coordinator</b>   | Prof. Dr. Uwe Dettmar/Professor Fakultät IME |
| <b>Lecturer(s)</b>          | Prof. Dr. Uwe Dettmar/Professor Fakultät IME |

### Learning Outcome(s)

Die Studierenden können in einer Forschungsgruppe ein Experiment teamorientiert planen, durchführen, auswerten und dokumentieren, indem sie auf biologisches und technisches Basiswissen und auf die zur Verfügung gestellten Ressourcen (ein IoT basiertes Mess- und Steuersystem inklusive FarmBot, Sensorik und Aktorik, Materialien und Geräte im Gewächshaus des Instituts für Pflanzenwissenschaften, Checklisten) sowie weitere frei verfügbare Informationsquellen zugreifen, um die Auswirkungen des Klimawandels auf die Wachstumsleistung von Pflanzen und die Biodiversität im Boden erfahrbar zu machen und dadurch Erkenntnisse zu generieren, die für die Gesellschaft im Rahmen des Klimawandels von Relevanz sind.

### Module Contents

#### *Seminar*

Development of project ideas, discussion and further development of the projects

#### *Project*

The students acquire...

- the ability to develop and implement concepts for the adaptation of plants to climate change.
- the ability to plan, conduct and analyze experiments in the fields of plant physiology, soil biology and technology.
- the ability to statistically evaluate and present experimental data.
- the ability to present and communicate scientific results.
- the ability to collaborate interdisciplinary and interculturallly and to exchange ideas with students from different MINT research areas.
- Experience in planning and implementing projects and in teamwork

At the end, students will have

- a deep understanding of the interactions between climate parameters, plant growth and soil biodiversity.
- basic knowledge of modern technologies such as robotics, sensor technology and the Internet of Things in the context of plant research.
- an awareness of the importance of sustainability, resource conservation and security of supply in the context of population growth and climate change.

|                                      |                                                                                |
|--------------------------------------|--------------------------------------------------------------------------------|
| <b>Teaching and Learning Methods</b> | <ul style="list-style-type: none"> <li>▪ Seminar</li> <li>▪ Project</li> </ul> |
|--------------------------------------|--------------------------------------------------------------------------------|

|                                       |                                                                                       |
|---------------------------------------|---------------------------------------------------------------------------------------|
| <b>Examination Types with Weights</b> | <ul style="list-style-type: none"> <li>▪ accompanying: project work [100%]</li> </ul> |
|---------------------------------------|---------------------------------------------------------------------------------------|

|                      |                      |
|----------------------|----------------------|
| <b>Workload</b>      | 150 Hours            |
| <b>Contact Hours</b> | 23 Hours $\pm$ 2 SWS |
| <b>Self-Study</b>    | 127 Hours            |



|                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Prerequisites</b>                 | <ul style="list-style-type: none"> <li>- fluent English since working intercultural and interdisciplinary teams.</li> <li>- basic knowledge in IoT and robotics desirable</li> <li>- ability to work in a team</li> <li>- basic knowledge in plant biology are not mandatory</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Mandatory Prerequisites</b>                   | <ul style="list-style-type: none"> <li>▪ Seminar requires attendance in the amount of: 8 Stunden</li> <li>▪ Project requires attendance in the amount of: 5 meetings for project discussions</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"> <li>▪ <a href="https://farm.bot/">https://farm.bot/</a></li> <li>▪ Arif, Tarik M.: Deep Learning on Embedded Systems: A Hands-On Approach Using Jetson Nano and Raspberry Pi, Wiley, 2025, ISBN:978-1-394-26927-3</li> <li>▪ Agrawal, D. P. (2017). Embedded Sensor Systems. Springer.</li> <li>▪ Marwedel, Peter: Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems, and the Internet of Things, Springer, 2021, ISBN 978-3-030-60910-8</li> <li>▪ L. Urry, S. Wassermann: Campbell Biology AP Edition (12th Edition), Pearson, ISBN-13: 978-0-13-648687-9</li> <li>▪ Taiz, L., Møller, I. M., Murphy, A., &amp; Zeiger, E. (2022). Plant Physiology and Development. Oxford University Press.</li> </ul> |
| <b>Included in Elective Catalog</b>              | WM - Allgemeiner Wahlmodulbereich                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Included in Specialization</b>                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"> <li>▪ IBD in Master Communication Systems and Networks PO3</li> <li>▪ IBD in Master Communication Systems and Networks PO4</li> <li>▪ IBD in Master Medientechnologie PO4</li> <li>▪ IBD in Master Technische Informatik PO3</li> <li>▪ IBD in Master Informatik und Systems-Engineering PO1</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Permanent Links to Organization</b>           | <a href="#"><u>Course description in the learning platform</u></a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Specifics and Notes</b>                       | Block course from the beginning of October to mid-November (7 weeks), optional preparation time to build up basic knowledge in the last week of September                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Last Update</b>                               | 19.7.2025, 14:32:16                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

## 6.16 ITF - IT-Forensik

|                             |                                                                                          |
|-----------------------------|------------------------------------------------------------------------------------------|
| <b>Module ID</b>            | ITF                                                                                      |
| <b>Module Name</b>          | IT-Forensik                                                                              |
| <b>Type of Module</b>       | Elective Modules                                                                         |
| <b>Recognized Course</b>    | ITF - IT forensics                                                                       |
| <b>ECTS credits</b>         | 5                                                                                        |
| <b>Language</b>             | deutsch, englisch bei Bedarf                                                             |
| <b>Duration of Module</b>   | 1 Semester                                                                               |
| <b>Recommended Semester</b> | 1-2                                                                                      |
| <b>Frequency of Course</b>  | every winter term                                                                        |
| <b>Module Coordinator</b>   | Studiengangsleiter(in) Master Technische Informatik / Informatik und Systems-Engineering |
| <b>Lecturer(s)</b>          | Jürgen Bornemann/Lehrbeauftragter                                                        |

### Learning Outcome(s)

- **WAS** Studierende spüren digitale Beweise auf und stellen Sie zwecks Verwertbarkeit für weiterführende Analysen sicher,
- **WOMIT** indem sie anhand fallbezogener Aufgabenstellungen und mittels forensischer IT-Tools Schwachstellen entdecken und Beweise in Dateisystemen und IT-Infrastrukturen sichern,
- **WOZU** um im Berufsleben Gefahren vermeiden, erkennen und abwehren können und ggf. gutachterlich tätig zu werden.

### Module Contents

#### Lecture / Exercises

Basic concepts of cyber security and digital forensics

Typical vulnerabilities, threats and risks

Dangers with mobile systems, home office, WLANs

Basics and working methods of IT forensics

Forensic documentation creation

Common tools for forensic investigations

Recognize and secure digital evidence

Open source forensics

File system forensics

Forensic analysis of mobile systems

Vulnerabilities, threats, attacks on network structures

KALI Linux - Operating System for Vulnerability and Pentesting

#### Project

Students can work on case-related forensic tasks and incidents independently or in working groups using the knowledge they have acquired. They show how to secure, analyze and document digital evidence.

**Teaching and Learning Methods**

- Lecture / Exercises
- Project

**Examination Types with Weights**

- accompanying: project work [100%]

**Workload** 150 Hours

**Contact Hours** 45 Hours  $\pm$  4 SWS

**Self-Study** 105 Hours

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**Recommended  
Prerequisites**

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**Mandatory  
Prerequisites**

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**Recommended  
Literature**

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**Included in Elective  
Catalog** WM - Allgemeiner Wahlmodulbereich

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**Included in  
Specialization**

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**Use of the Module in  
Other Study Programs**

- ITF in Master Communication Systems and Networks PO3
- ITF in Master Communication Systems and Networks PO4
- ITF in Master Elektrotechnik PO3
- ITF in Master Medientechnologie PO3
- ITF in Master Medientechnologie PO4
- ITF in Master Technische Informatik PO3
- ITF in Master Informatik und Systems-Engineering PO1

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**Specifics and Notes**

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**Last Update** 19.7.2025, 14:32:16

**6.17 KOLL - Kolloquium zur Masterarbeit**

|                                       |                                                                                                                                                                                                                                                                                                                                        |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Module ID</b>                      | KOLL                                                                                                                                                                                                                                                                                                                                   |
| <b>Module Name</b>                    | Kolloquium zur Masterarbeit                                                                                                                                                                                                                                                                                                            |
| <b>Type of Module</b>                 | Mandatory Module                                                                                                                                                                                                                                                                                                                       |
| <b>Recognized Course</b>              | MAKOLL - Colloquium                                                                                                                                                                                                                                                                                                                    |
| <b>ECTS credits</b>                   | 3                                                                                                                                                                                                                                                                                                                                      |
| <b>Language</b>                       | deutsch, englisch bei Bedarf                                                                                                                                                                                                                                                                                                           |
| <b>Duration of Module</b>             | 1 Semester                                                                                                                                                                                                                                                                                                                             |
| <b>Recommended Semester</b>           | 3                                                                                                                                                                                                                                                                                                                                      |
| <b>Frequency of Course</b>            | every term                                                                                                                                                                                                                                                                                                                             |
| <b>Module Coordinator</b>             | Studiengangsleiter(in) Master Technische Informatik / Informatik und Systems-Engineering                                                                                                                                                                                                                                               |
| <b>Lecturer(s)</b>                    | verschiedene Dozenten*innen / diverse lecturers                                                                                                                                                                                                                                                                                        |
| <b>Learning Outcome(s)</b>            | <ul style="list-style-type: none"> <li>- Darstellung von Forschungsergebnissen in einer Präsentation in vorgegebenem engen zeitlichen Rahmen</li> <li>- Fachliche und außerfachliche Bezüge der eigenen Arbeit darstellen und begründen</li> <li>- Eigene Lösungswege und gewonnene Erkenntnisse darstellen und diskutieren</li> </ul> |
| <b>Module Contents</b>                |                                                                                                                                                                                                                                                                                                                                        |
| <b>Colloquium</b>                     | <p>The colloquium serves to determine whether the student is able to present the results of the Master's thesis, its technical and methodological foundations, interdisciplinary contexts and extracurricular references orally, to justify them independently and to assess their significance for practice</p>                       |
| <b>Teaching and Learning Methods</b>  | Colloquium                                                                                                                                                                                                                                                                                                                             |
| <b>Examination Types with Weights</b> | <ul style="list-style-type: none"> <li>▪ final: Colloquium [100%]</li> </ul>                                                                                                                                                                                                                                                           |
| <b>Workload</b>                       | 90 Hours                                                                                                                                                                                                                                                                                                                               |
| <b>Contact Hours</b>                  | 0 Hours $\triangleq$ 0 SWS                                                                                                                                                                                                                                                                                                             |
| <b>Self-Study</b>                     | 90 Hours                                                                                                                                                                                                                                                                                                                               |
| <b>Recommended Prerequisites</b>      |                                                                                                                                                                                                                                                                                                                                        |
| <b>Mandatory Prerequisites</b>        | <ul style="list-style-type: none"> <li>▪ Module MAA: Die Masterarbeit muss abgeschlossen sein, damit sie im Kolloquium ganzheitlich und abschließend präsentiert werden kann.</li> <li>▪ See exam regulations §29, paragraph 2</li> </ul>                                                                                              |
| <b>Recommended Literature</b>         |                                                                                                                                                                                                                                                                                                                                        |
| <b>Included in Elective Catalog</b>   |                                                                                                                                                                                                                                                                                                                                        |
| <b>Included in Specialization</b>     |                                                                                                                                                                                                                                                                                                                                        |

|                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"><li>▪ KOLL in Master Communication Systems and Networks PO3</li><li>▪ KOLL in Master Communication Systems and Networks PO4</li><li>▪ KOLL in Master Elektrotechnik PO3</li><li>▪ KOLL in Master Medientechnologie PO3</li><li>▪ KOLL in Master Medientechnologie PO4</li><li>▪ KOLL in Master Technische Informatik PO3</li><li>▪ KOLL in Master Informatik und Systems-Engineering PO1</li></ul> |
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| <b>Specifics and Notes</b> | See also examination regulations §29. |
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## 6.18 LCSS - Large and Cloud-based Software-Systems

|                             |                                                  |
|-----------------------------|--------------------------------------------------|
| <b>Module ID</b>            | LCSS                                             |
| <b>Module Name</b>          | Large and Cloud-based Software-Systems           |
| <b>Type of Module</b>       | Elective Modules                                 |
| <b>Recognized Course</b>    | LCSS - Large and Cloud-based Software-Systems    |
| <b>ECTS credits</b>         | 5                                                |
| <b>Language</b>             | englisch                                         |
| <b>Duration of Module</b>   | 1 Semester                                       |
| <b>Recommended Semester</b> | 1-2                                              |
| <b>Frequency of Course</b>  | every summer term                                |
| <b>Module Coordinator</b>   | Prof. Dr. René Wörzberger/Professor Fakultät IME |
| <b>Lecturer(s)</b>          | Prof. Dr. René Wörzberger/Professor Fakultät IME |

### Learning Outcome(s)

Students are capable of

- designing architectures for complex and mission critical enterprise software systems,
- implementing these systems and
- operate them in the Cloud

by

- knowing and trading conflicting interests and concerns of stakeholders,
- knowing quality attributes and their trade-offs,
- specifying architecturally significant requirements in quality attribute scenarios,
- analysing design decisions with respect to their effects on quality attributes and stake-holder interests and concerns,
- presenting and documenting architectures by means of suitable views, notations and tools,
- applying methods (like RESTful API design) and tools in order to implement design decisions,
- using cloud resources like virtual machines, containers and storages in order to operate a system in the cloud,

in order to

- be able to produce long-term usable software systems in subsequent lectures and projects and
- to be able to act as an IT architect, e.g. in an IT department of a larger enterprise.

**Module Contents****Lecture / Exercises**

- Formally sound handling of quality requirements for availability, performance, capacity and cost efficiency
- Advantages and disadvantages of basic system architecture styles, such as microservice architectures
- Scaling of systems and individual tiers, also with regard to possible deployment strategies such as canary or AB deployment, as well as associated load balancing strategies (e.g. consistent hashing)
- Advanced applications of virtualization, in particular container virtualization and orchestration, for example with Docker and Kubernetes
- Selection of suitable communication patterns and protocols, in particular HTTP and derivatives such as websockets, server-sent events and gRPC
- Selection of appropriate API technologies and design philosophies such as REST and GraphQL
- Use of basic security protocols such as TLS, OAuth2, JWT and OpenID Connect
- Asynchronous, event-driven communication via messaging and streaming platforms such as Apache Kafka
- Selection of suitable database models (relational, key-value-, graph-, document-oriented), necessary consistency level, as well as sharding using the example of PostgreSQL, Neo4J, Apache Cassandra and Redis
- Strategies for caching data, in particular HTTP responses (web caching).

**Project**

- Be able to formulate and present a research question in the topic area of the course.
- Design an application prototype that serves to investigate the research question.
- Develop the application prototype and run it in the cloud
- Design and conduct test scenarios and experiments with the application prototype to answer the research question.

|                                      |                                                                                            |
|--------------------------------------|--------------------------------------------------------------------------------------------|
| <b>Teaching and Learning Methods</b> | <ul style="list-style-type: none"> <li>▪ Lecture / Exercises</li> <li>▪ Project</li> </ul> |
|--------------------------------------|--------------------------------------------------------------------------------------------|

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| <b>Examination Types with Weights</b> | <ul style="list-style-type: none"> <li>▪ accompanying: project work [60%] and</li> <li>▪ final: (digital) written exam or oral examination [40%]</li> </ul> |
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| <b>Workload</b> | 150 Hours |
|-----------------|-----------|

|                      |                      |
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| <b>Contact Hours</b> | 45 Hours $\pm$ 4 SWS |
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| <b>Self-Study</b> | 105 Hours |
|-------------------|-----------|

|                                  |                                                                                                                                                                                                                                                                                           |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Prerequisites</b> | <ul style="list-style-type: none"> <li>- advanced programming skills</li> <li>- basic knowledge of web technologies</li> <li>- basic knowledge of databases</li> <li>- basic knowledge in software architectures</li> <li>- basic knowledge of Unified Modeling Language (UML)</li> </ul> |
|----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

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|--------------------------------|---------------------------------------------------------|
| <b>Mandatory Prerequisites</b> | Project requires attendance in the amount of: 4 Termine |
|--------------------------------|---------------------------------------------------------|

|                               |                                                                                                                                                                                                                                                                                                                                                                         |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Literature</b> | <ul style="list-style-type: none"> <li>▪ Lecture Notes Large and Cloud-based Software Systems</li> <li>▪ H. Adkins et al.: Building Secure and Reliable Systems, O'Reilly Media, 2020</li> <li>▪ I. Gregorik: High Performance Browser Networking, O'Reilly Media, 2013</li> <li>▪ M. Kleppmann: Designing Data-Intensive Applications, O'Reilly Media, 2017</li> </ul> |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

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| <b>Included in Elective Catalog</b> | WM - Allgemeiner Wahlmodulbereich |
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| <b>Included in Specialization</b> |  |
|-----------------------------------|--|

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| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"><li>▪ LCSS in Master Communication Systems and Networks PO3</li><li>▪ LCSS in Master Communication Systems and Networks PO4</li><li>▪ LCSS in Master Medientechnologie PO4</li><li>▪ LCSS in Master Technische Informatik PO3</li><li>▪ LCSS in Master Informatik und Systems-Engineering PO1</li></ul> |
|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                        |                                   |
|----------------------------------------|-----------------------------------|
| <b>Permanent Links to Organization</b> | <a href="#"><u>llu course</u></a> |
|----------------------------------------|-----------------------------------|

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**Specifics and Notes**

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| <b>Last Update</b> | 19.7.2025, 14:32:16 |
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**6.19 LSPW - Leistungselektronische Stellglieder für PV- und Windkraftanlagen**

|                             |                                                                  |
|-----------------------------|------------------------------------------------------------------|
| <b>Module ID</b>            | LSPW                                                             |
| <b>Module Name</b>          | Leistungselektronische Stellglieder für PV- und Windkraftanlagen |
| <b>Type of Module</b>       | Elective Modules                                                 |
| <b>Recognized Course</b>    | LSPW - Power Electronics for PV and Wind                         |
| <b>ECTS credits</b>         | 5                                                                |
| <b>Language</b>             | deutsch                                                          |
| <b>Duration of Module</b>   | 1 Semester                                                       |
| <b>Recommended Semester</b> | 1-2                                                              |
| <b>Frequency of Course</b>  | every winter term                                                |
| <b>Module Coordinator</b>   | Prof. Dr. Andreas Lohner/Professor Fakultät IME                  |
| <b>Lecturer(s)</b>          | Prof. Dr. Christian Dick/Professor Fakultät IME                  |

**Learning Outcome(s)**

Die Studierenden lernen elektronische und elektromagnetische Strukturen, Topologien und Regelungsverfahren verschiedener erneuerbarer Energieerzeugungsanlagen (Photovoltaik & Wind) erläutern, erklären und z. T. auch entwickeln, indem sie

- die gesamte anlagenspezifische Systemtechnik in wesentliche Teile (Elektromechanik, Leistungselektronik, Steuerung/Regelung) gliedern,
- Rechnermodelle von allen Teilen und auch der Gesamtanlage entwerfen und mit einem Simulationstool simulieren,
- mit Leistungselektronik, Antrieben, klassischen Messgeräten umgehen,
- sowie spezifische Regelungsalgorithmen erkennen und verstehen,

um als Ingenieure

- Erneuerbare Energieerzeugungsanlagen zu konzeptionieren und zu dimensionieren,
- Leistungselektronische Komponenten für EE zu entwickeln und
- für EE spezifische Regelungen zu entwerfen.

**Module Contents****Lecture / Exercises**

Overview of the different renewable energy sources and their potentials Photovoltaic, Wind power etc.

Principles of grid-connected as well as of idle solar inverters for photovoltaic systems

Physics of the solar cell

Inverter topologies

System architectures: central, string and module inverters

Control methods: PWM, MPP tracking etc.

Principles of wind turbines

double-fed induction machine

Plant with synchronous machine

Wind power-specific control algorithms

The students will be able to explain electronic and electromagnetic structures, topologies and control methods of various renewable energy generation systems (photovoltaic, wind, etc.).

The students possess the ability to dissect the entire plant-specific system technology into essential subsections, to develop or to project individual aspects and thus to carry out individual steps of a synthesis.

The relationship to reality, in particular with regard to new regulatory, normative framework conditions that accompany the energy transition, is being established. This enables the student to describe the actuators as part of an intelligent network in the superordinate context in order to later select or develop the correct actuators.

The students become acquainted with methods for the dynamic description and regulation of renewable energy generation plants and thereby obtain decision-making authority.

The students have experience in handling power electronics, drives, classical measuring devices and are able to model actuators with a simulation tool.

Students have the ability to understand, dimension and regulate electrical actuators for renewable energy generation.

**Lab**

In a first experiment, an inverter for a photovoltaic system is modeled as an example and simulated with a simulation tool. Special attention is paid to the plant-specific regulatory procedures (MPP tracking, etc.). Thereafter, a commercial inverter is measured and analyzed.

In a second experiment, a double-fed induction machine including converters is being investigated as an actuator for wind turbines.

Students can handle a standard commercial modeling and simulation tool.

The students understand the working behavior of power electronic actuators.

The students can solve tasks in a small team.

They can analyze measurement results and gain insights into the measurement object.

They can model and simulate a real system.

**Teaching and Learning** ■ Lecture / Exercises

**Methods** ■ Lab

**Examination Types with** ■ accompanying: lab report or oral contribution [ungraded] and

**Weights** ■ final: oral examination [100%]

**Workload** 150 Hours

**Contact Hours** 45 Hours  $\pm$  4 SWS

**Self-Study** 105 Hours

**Recommended Prerequisites** Fundamentals of electrical engineering  
power electronics  
Basics of electric drives  
Analogue signals and systems

**Mandatory Prerequisites** Lab requires attendance in the amount of: Labortermine (8 Std.)

|                               |                                                                                                                                                                                                                                                                                                                                                                                      |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Literature</b> | <ul style="list-style-type: none"> <li>▪ Hau E.: Windkraftanlagen - Grundlagen, Technik, Einsatz, Wirtschaftlichkeit, Springer Verlag</li> <li>▪ Mertens, K.: Photovoltaik - Lehrbuch zu Grundlagen, Technologie und Praxis, Hanser Verlag</li> <li>▪ Sahan, B.: Wechselrichtersysteme mit Stromzwischenkreis zur Netzanbindung von Photovoltaik-Generatoren, KDEE Kassel</li> </ul> |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

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|-------------------------------------|-----------------------------------|
| <b>Included in Elective Catalog</b> | WM - Allgemeiner Wahlmodulbereich |
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**Included in Specialization**

|                                                  |                                                                                                                                                                                                                         |
|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"> <li>▪ LSPW in Master Communication Systems and Networks PO3</li> <li>▪ LSPW in Master Communication Systems and Networks PO4</li> <li>▪ LSPW in Master Elektrotechnik PO3</li> </ul> |
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**Specifics and Notes**

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**Additional module variant with same learning outcomes**

|                             |                                                                  |
|-----------------------------|------------------------------------------------------------------|
| <b>Module ID</b>            | LSPW                                                             |
| <b>Module Name</b>          | Leistungselektronische Stellglieder für PV- und Windkraftanlagen |
| <b>Type of Module</b>       | Elective Modules                                                 |
| <b>Recognized Course</b>    | LSPW - Power Electronics for PV and Wind                         |
| <b>ECTS credits</b>         | 5                                                                |
| <b>Language</b>             | deutsch                                                          |
| <b>Duration of Module</b>   | 1 Semester                                                       |
| <b>Recommended Semester</b> | 1-2                                                              |
| <b>Frequency of Course</b>  | every winter term                                                |
| <b>Module Coordinator</b>   | Prof. Dr. Andreas Lohner/Professor Fakultät IME                  |
| <b>Lecturer(s)</b>          | Prof. Dr. Christian Dick/Professor Fakultät IME                  |

**Learning Outcome(s)**

Die Studierenden lernen elektronische und elektromagnetische Strukturen, Topologien und Regelungsverfahren verschiedener erneuerbarer Energieerzeugungsanlagen (Photovoltaik & Wind) erläutern, erklären und z. T. auch entwickeln, indem sie

- die gesamte anlagenspezifische Systemtechnik in wesentliche Teile (Elektromechanik, Leistungselektronik, Steuerung/Regelung) gliedern,
- Rechnermodelle von allen Teilen und auch der Gesamtanlage entwerfen und mit einem Simulationstool simulieren,
- mit Leistungselektronik, Antrieben, klassischen Messgeräten umgehen,
- sowie spezifische Regelungsalgorithmen erkennen und verstehen,

um als Ingenieure

- Erneuerbare Energieerzeugungsanlagen zu konzeptionieren und zu dimensionieren,
- Leistungselektronische Komponenten für EE zu entwickeln und
- für EE spezifische Regelungen zu entwerfen.

**Module Contents****Lecture / Exercises**

Overview of the different renewable energy sources and their potentials Photovoltaic, Wind power etc.

Principles of grid-connected as well as of idle solar inverters for photovoltaic systems

Physics of the solar cell

Inverter topologies

System architectures: central, string and module inverters

Control methods: PWM, MPP tracking etc.

Principles of wind turbines

double-fed induction machine

Plant with synchronous machine

Wind power-specific control algorithms

The students will be able to explain electronic and electromagnetic structures, topologies and control methods of various renewable energy generation systems (photovoltaic, wind, etc.).

The students possess the ability to dissect the entire plant-specific system technology into essential subsections, to develop or to project individual aspects and thus to carry out individual steps of a synthesis.

The relationship to reality, in particular with regard to new regulatory, normative framework conditions that accompany the energy transition, is being established. This enables the student to describe the actuators as part of an intelligent network in the superordinate context in order to later select or develop the correct actuators.

The students become acquainted with methods for the dynamic description and regulation of renewable energy generation plants and thereby obtain decision-making authority.

The students have experience in handling power electronics, drives, classical measuring devices and are able to model actuators with a simulation tool.

Students have the ability to understand, dimension and regulate electrical actuators for renewable energy generation.

**Lab**

In a first experiment, an inverter for a photovoltaic system is modeled as an example and simulated with a simulation tool. Special attention is paid to the plant-specific regulatory procedures (MPP tracking, etc.). Thereafter, a commercial inverter is measured and analyzed.

In a second experiment, a double-fed induction machine including converters is being investigated as an actuator for wind turbines.

Students can handle a standard commercial modeling and simulation tool.

The students understand the working behavior of power electronic actuators.

The students can solve tasks in a small team.

They can analyze measurement results and gain insights into the measurement object.

They can model and simulate a real system.

**Teaching and Learning**      ■ Lecture / Exercises

**Methods**                      ■ Lab

**Examination Types with**      ■ accompanying: oral contribution [ungraded] and

**Weights**                        ■ final: oral examination [100%]

**Workload**                      150 Hours

**Contact Hours**                45 Hours  $\pm$  4 SWS

**Self-Study**                      105 Hours

**Recommended**                Fundamentals of electrical engineering  
**Prerequisites**                   power electronics  
                                          Basics of electric drives  
                                          Analogue signals and systems

**Mandatory**                      Lab requires attendance in the amount of: 8 Unterrichtsstunden  
**Prerequisites**

|                               |                                                                                                                                                                                                                                                                                                                                                                                      |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Literature</b> | <ul style="list-style-type: none"> <li>▪ Hau E.: Windkraftanlagen - Grundlagen, Technik, Einsatz, Wirtschaftlichkeit, Springer Verlag</li> <li>▪ Mertens, K.: Photovoltaik - Lehrbuch zu Grundlagen, Technologie und Praxis, Hanser Verlag</li> <li>▪ Sahan, B.: Wechselrichtersysteme mit Stromzwischenkreis zur Netzanbindung von Photovoltaik-Generatoren, KDEE Kassel</li> </ul> |
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|                                     |                                   |
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| <b>Included in Elective Catalog</b> | WM - Allgemeiner Wahlmodulbereich |
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**Included in Specialization**

|                                                  |                                                                                                                                                                                                                         |
|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"> <li>▪ LSPW in Master Communication Systems and Networks PO3</li> <li>▪ LSPW in Master Communication Systems and Networks PO4</li> <li>▪ LSPW in Master Elektrotechnik PO3</li> </ul> |
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**Specifics and Notes**

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## 6.20 MAA - Masterarbeit

|                             |                                                                                          |
|-----------------------------|------------------------------------------------------------------------------------------|
| <b>Module ID</b>            | MAA                                                                                      |
| <b>Module Name</b>          | Masterarbeit                                                                             |
| <b>Type of Module</b>       | Mandatory Module                                                                         |
| <b>Recognized Course</b>    | MAA - Master thesis                                                                      |
| <b>ECTS credits</b>         | 27                                                                                       |
| <b>Language</b>             | deutsch, englisch bei Bedarf                                                             |
| <b>Duration of Module</b>   | 1 Semester                                                                               |
| <b>Recommended Semester</b> | 3                                                                                        |
| <b>Frequency of Course</b>  | every term                                                                               |
| <b>Module Coordinator</b>   | Studiengangsleiter(in) Master Technische Informatik / Informatik und Systems-Engineering |
| <b>Lecturer(s)</b>          | verschiedene Dozenten*innen / diverse lecturers                                          |

### Learning Outcome(s)

Das Modul vermittelt folgende Kenntnisse und Fertigkeiten:

- Komplexe Aufgabenstellungen beurteilen
- Selbstständiges Verfassen eines längeren wissenschaftlichen Textes
- Gute Praxis des wissenschaftlichen Arbeitens anwenden
- Darstellung von Forschungsergebnissen in Form eines wissenschaftlichen Artikels nach den Vorgaben gängiger Fachzeitschriften bzw. Konferenzen
- Selbstständiges und systematisches Bearbeiten einer komplexen ingenieurwissenschaftlichen Aufgabenstellung unter Verwendung wissenschaftlicher Methoden
- Lösungsstrategien entwickeln und umsetzen
- Wissenschaftliche Literatur recherchieren und auswerten
- Eigene Arbeit bewerten und einordnen

Individuelle Vereinbarung des Studierenden mit einem Dozenten der MT bzw. F07 über eine qualifizierte Ingenieur Tätigkeit mit einer studiengangsbezogenen Aufgabenstellung mit wissenschaftlichem Anspruch. Die Masterarbeit kann auch extern in einer Forschungsorganisation, einem Wirtschaftsunternehmen o.ä. durchgeführt werden. Die Betreuung erfolgt durch den Dozenten. Die Masterarbeit adressiert die Entwicklung komplexer Medientechnologien unter interdisziplinären Bedingungen (HF1) und das wissenschaftliche Arbeiten um wissenschaftliche Erkenntnisse zu erweitern (HF2)."

### Module Contents

#### Thesis

The Master's thesis is a written assignment. It should show that the student is capable of independently working on a topic from his or her subject area within a specified period of time, both in its technical details and in its interdisciplinary contexts, using scientific and practical methods. Interdisciplinary cooperation can also be taken into account in the final thesis.

### Teaching and Learning

Thesis

#### Methods

### Examination Types with Weights

- final: Thesis [100%]

|                                  |                                      |
|----------------------------------|--------------------------------------|
| <b>Workload</b>                  | 810 Hours                            |
| <b>Contact Hours</b>             | 0 Hours $\pm$ 0 SWS                  |
| <b>Self-Study</b>                | 810 Hours                            |
| <b>Recommended Prerequisites</b> | See examination regulations §26      |
| <b>Mandatory Prerequisites</b>   | see exam regulations §26 paragraph 1 |

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**Recommended  
Literature**

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**Included in Elective  
Catalog**

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**Included in  
Specialization**

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|                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                               |
|------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Use of the Module in<br/>Other Study Programs</b> | <ul style="list-style-type: none"><li>■ MAA in Master Communication Systems and Networks PO3</li><li>■ MAA in Master Communication Systems and Networks PO4</li><li>■ MAA in Master Elektrotechnik PO3</li><li>■ MAA in Master Medientechnologie PO3</li><li>■ MAA in Master Medientechnologie PO4</li><li>■ MAA in Master Technische Informatik PO3</li><li>■ MAA in Master Informatik und Systems-Engineering PO1</li></ul> |
|------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

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|                            |                                                                                                                                |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| <b>Specifics and Notes</b> | See also examination regulations §24ff. Contact a professor of the faculty early on for the initial supervision of the thesis. |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------------|

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|--------------------|---------------------|
| <b>Last Update</b> | 19.7.2025, 14:32:16 |
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**6.21 MLWR - Maschinelles Lernen und wissenschaftliches Rechnen**

|                             |                                                    |
|-----------------------------|----------------------------------------------------|
| <b>Module ID</b>            | MLWR                                               |
| <b>Module Name</b>          | Maschinelles Lernen und wissenschaftliches Rechnen |
| <b>Type of Module</b>       | Elective Modules                                   |
| <b>Recognized Course</b>    | MLWR - Machine Learning and Scientific Computing   |
| <b>ECTS credits</b>         | 5                                                  |
| <b>Language</b>             | deutsch                                            |
| <b>Duration of Module</b>   | 1 Semester                                         |
| <b>Recommended Semester</b> | 1-2                                                |
| <b>Frequency of Course</b>  | every summer term                                  |
| <b>Module Coordinator</b>   | Prof. Dr. Beate Rhein/Professor Fakultät IME       |
| <b>Lecturer(s)</b>          | Prof. Dr. Beate Rhein/Professor Fakultät IME       |

**Learning Outcome(s)**

Was:

fortgeschrittene Methoden des maschinellen Lernens auf typische Datensätze der technischen Informatik anwenden  
Fallstricke des Maschinellen Lernens in der Vorgehensweise erkennen  
für eine Aufgabenstellung das geeignete Verfahren bestimmen und anwenden können  
Qualität von Datensätzen beurteilen und verbessern  
Datenschutzgesetze kennen  
weit verbreitete Software des maschinellen Lernens anwenden

Womit:

Die Methoden werden anhand eines Vortrags oder per Lernvideos vermittelt und in Vorlesung und Übung direkt angewendet. Jeder Student wird ein Projekt durchführen (je nach Anzahl der Studierenden in Gruppenarbeit), bei der er sich Teile des Stoffes selber erarbeitet.

Wozu:

Maschinelles Lernen wird bei den späteren Arbeitgebern immer mehr eingeführt, etwa in der Robotik, aber auch zur Überwachung und Steuerung von Produktionsprozessen oder Energiesystemen und zur Auswertung von Kundendaten, hier ist ein verantwortlicher Einsatz von Daten wichtig.



**Module Contents****Lecture / Exercises**

Approximation methods  
metamodeling  
regression

Multi-criteria optimization  
formulation  
Pareto front  
algorithms  
visualization

Advanced Cluster Analysis

Association Pattern Mining

Outlier Detection

Advanced classification procedures

possibly text recognition, web mining, time series analysis

**Lab**

Apply and program methods of approximation, multicriteria optimization or machine learning  
efficiently implement numerical methods  
Evaluate the complexity of algorithms

**Teaching and Learning Methods**

- Lecture / Exercises
- Lab

**Examination Types with Weights**

- accompanying: project work [20%] and
- final: oral examination [80%]

**Workload** 150 Hours

**Contact Hours** 45 Hours  $\pm$  4 SWS

**Self-Study** 105 Hours

**Recommended Prerequisites** Basic knowledge of probability theory and machine learning

**Mandatory Prerequisites**

- Lecture / Exercises requires attendance in the amount of: 6 Stunden
- Lab requires attendance in the amount of: 2 Termine
- Participation in final examination only after successful participation in Lab

**Recommended Literature**

- A. Geron: Hand-on Machine Learning, O'Reilly Verlag
- J. Alammar: Hands-on Large Language Models, O'Reilly Verlag

**Included in Elective Catalog** WM - Allgemeiner Wahlmodulbereich

**Included in Specialization**

**Use of the Module in Other Study Programs**

- MLWR in Master Elektrotechnik PO3
- MLWR in Master Medientechnologie PO4
- MLWR in Master Technische Informatik PO3
- MLWR in Master Informatik und Systems-Engineering PO1

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**Specifics and Notes**

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**Last Update** 19.7.2025, 14:32:16

## 6.22 NGN - Next Generation Networks

|                             |                                                |
|-----------------------------|------------------------------------------------|
| <b>Module ID</b>            | NGN                                            |
| <b>Module Name</b>          | Next Generation Networks                       |
| <b>Type of Module</b>       | Elective Modules                               |
| <b>Recognized Course</b>    | NGN - Next Generation Networks                 |
| <b>ECTS credits</b>         | 5                                              |
| <b>Language</b>             | englisch                                       |
| <b>Duration of Module</b>   | 1 Semester                                     |
| <b>Recommended Semester</b> | 1-2                                            |
| <b>Frequency of Course</b>  | every summer term                              |
| <b>Module Coordinator</b>   | Prof. Dr. Andreas Grebe/Professor Fakultät IME |
| <b>Lecturer(s)</b>          | Prof. Dr. Andreas Grebe/Professor Fakultät IME |

### Learning Outcome(s)

What?

Understanding architectures and service signalling in Next Generation Networks (All-IP Networks). Competences to evaluate, analyze, design, implement and test NGN components and service areas with heterogeneous service requirements.

How?

Based on Bachelor-level competences on IP networking and services, students learn standards, design principles, architectures and sample implementations of Next Generation Networks and services in lectures and exercises. In a small team and organized as semester project, students develop their own NGN service solution, optionally based on existing systems, and learn how to design, implement and analyze their own service solution.

What for?

To be able to design, analyze, select, use and apply actual and future network services, based on All-IP networks for enterprise networks, telecommunication networks and mobile networks.

### Module Contents

#### Lecture / Exercises

Achieve basic understanding and implementation knowledge on Next Generation Network (NGN) definition by ITU-T, IP Multimedia Subsystem by 3GPP, and ETSI, and Next Generation Internet (NGI) definition by IETF, ITU-T standards, Multimedia Services in NGN, VoIP, Video-over-IP, RTP encapsulation, Service Signaling, SIP protocol, SIP Digest Authentication, SDP service description and capabilities, SIP servers, Session Border Controller (SBC), SIP Gateway Technologies, SIP routing, NAT Gateways, NAT solution, SRR, STUN, TURN, IMS in mobile networks, IMS in fixed-line networks, VoIP in enterprise networks. IMS in virtualized core network.

Students evaluate requirements for NGN services and plan, implement and analyze NGN services based on SIP signalling or alternative signalling protocols. They are competent in functional analysis and troubleshooting by deep packet inspection (DPI) protocol analysis. They evaluate the performance of NGN services in terms of timing, throughput, latency and delays, jitter, robustness in case of packet errors, and security aspects.

#### Lab

Naming, structuring and classifying concepts and technologies for NGNs or NGIs. Demonstrate network analysis techniques and tools, know methods for NGN services and network planning.

Working on a small project in a tiny team (2-3 team members) on actual technologies in the area of NGN services and NGI services. Set-up an NGN/NGI environment and NGN service, including planning, implementation and evaluation of security aspects and protocol analysis plus performance evaluation.

The results are reviewed during the course period, summarised in a report and presented to the class. Individual project proposals by students are welcome.

|                                      |                                                                                        |
|--------------------------------------|----------------------------------------------------------------------------------------|
| <b>Teaching and Learning Methods</b> | <ul style="list-style-type: none"> <li>■ Lecture / Exercises</li> <li>■ Lab</li> </ul> |
|--------------------------------------|----------------------------------------------------------------------------------------|

|                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Examination Types with Weights</b>            | <ul style="list-style-type: none"> <li>■ accompanying: exercise lab [ungraded] and</li> <li>■ final: (digital) written exam or oral examination [100%]</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Workload</b>                                  | 150 Hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Contact Hours</b>                             | 45 Hours $\pm$ 4 SWS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Self-Study</b>                                | 105 Hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Recommended Prerequisites</b>                 | <ul style="list-style-type: none"> <li>■ Modul BSN: Bachelor Level Networking Knowledge and Skills like taught in BSN. Fundamentals of Networks and Protocols (typically Bachelor Level) Layered Communications and Protocol Stacks (ISO/OSI, IETF TCP/IP, IEEE), LAN, MAN, WAN, Fixed Line and Mobile Network Fundamentals, Data Link-Technologies (Ethernet, WiFi), IP-Networking (IPv4, IPv6), IP Routing Protocols (static Routes, RIP, OSPF, BGP), Transport Protocols (TCP (incl. Flow Control / Congestion Control), UDP) and Port Numbers, Application Protocols (HTTP, Request-Response Pattern, Publish-Subscribe Pattern).</li> <li>■ Bachelor-level knowledge of protocols and layer models, Internet protocols (UDP, TCP, IP, HTTP, FTP), IP addressing (IPv4, IPv6), routing techniques (IP routing, functionality of a router, routing protocols, RIP, OSPF), transmission systems and layer 2 protocols, Ethernet.</li> </ul> <p>Understanding distributed systems and applications, sockets and client/server programming, request-response patterns, publish-subscribe patterns.</p> |
| <b>Mandatory Prerequisites</b>                   | <ul style="list-style-type: none"> <li>■ Lab requires attendance in the amount of: 6 Meilensteintermine und Projektvorstellungen</li> <li>■ Participation in final examination only after successful participation in Lab</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"> <li>■ J. Kurose, K. Ross: Computer Networking: A Top-Down Approach, Global Edition, Prentice Hall, 7th ed., 2016</li> <li>■ A. S. Tanenbaum, D. J. Wetherall: Computer Networks, Pearson, 5th ed., 2013</li> <li>■ U. Trick, F. Weber: SIP und Telekommunikationsnetze: Next Generation Networks und Multimedia over IP – konkret, De Gruyter Oldenbourg Verlag, 4. Auflage 2015</li> <li>■ J. F. Durkin: Voice-enabling the Data Network, Cisco Press 2010</li> <li>■ G. Camarillo, M.A. García-Martín: The 3G IP Multimedia Subsystem (IMS), John Wiley Verlag, 2006</li> <li>■ W. Stallings: Foundations of Modern Networking, Pearson Education, 2016</li> <li>■ J. Doherty: SDN and NFV Simplified, Pearson Education, 2016</li> <li>■ J. Edelman: Network Programmability and Automation, O'Reilly 2018</li> <li>■ J. van Meggelen, R. Bryant, L. Madsen: Asterisk: The Definitive Guide: Open Source Telephony for the Enterprise, O'Reilly Media, 5th Ed. 2019</li> </ul>                                                                                   |
| <b>Included in Elective Catalog</b>              | WM - Allgemeiner Wahlmodulbereich                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Included in Specialization</b>                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"> <li>■ NGN in Master Communication Systems and Networks PO3</li> <li>■ NGN in Master Communication Systems and Networks PO4</li> <li>■ NGN in Master Technische Informatik PO3</li> <li>■ NGN in Master Informatik und Systems-Engineering PO1</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Last Update</b>                               | 19.7.2025, 14:32:16                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

**6.23 NLO - Nichtlineare Optik**

|                             |                                                |
|-----------------------------|------------------------------------------------|
| <b>Module ID</b>            | NLO                                            |
| <b>Module Name</b>          | Nichtlineare Optik                             |
| <b>Type of Module</b>       | Elective Modules                               |
| <b>Recognized Course</b>    | NLO - Nonlinear optics                         |
| <b>ECTS credits</b>         | 5                                              |
| <b>Language</b>             | deutsch                                        |
| <b>Duration of Module</b>   | 1 Semester                                     |
| <b>Recommended Semester</b> | 1-2                                            |
| <b>Frequency of Course</b>  | every summer term                              |
| <b>Module Coordinator</b>   | Prof. Dr. Uwe Oberheide/Professor Fakultät IME |
| <b>Lecturer(s)</b>          | Prof. Dr. Uwe Oberheide/Professor Fakultät IME |

**Learning Outcome(s)**

Die Studierenden verstehen die grundlegenden Eigenschaften von Licht und Materie bei hohen Lichtintensitäten, indem sie die zugrunde liegenden Prozesse mathematisch, physikalisch und technisch analysieren und in idealisierter Umgebung beschreiben, damit sie in ihrer Abschlussarbeit und Berufsalltag passende Komponenten und Verfahren zur Lichtbeeinflussung und Materialbearbeitung insbesondere mit ultrakurzen Laserpulsen auswählen können.

---

**Module Contents****Lecture / Exercises**

Optical frequency multiplication (crystal coherence lengths, phase matching, quasi phase matching and periodic polarity)  
 Frequency mixing  
 Optical-parametric oscillation and amplification  
 Electro-, magneto- and acousto-optical effects  
 Q-switch, mode coupling, ultrashort pulse laser  
 Application of multiphoton processes  
 Photorefraction, stimulated Brillouin scattering, phase conjugating mirrors

Recognizing analogies of known linear physical processes (light-matter interaction at low intensity) and transferring them to nonlinear processes  
 Describe processes mathematically and transfer the result into physical effects  
 Transfer idealized systems to real systems and derive qualitative behavior  
 Describe and explain correlations of quantities (saturable absorption / multidimensional refractive index) and transfer them to real materials.  
 Analyze technical applications and problems, break them down into individual processes and solve them using known nonlinear interactions.

**Seminar**

Presentations on applications/processes based on the content of the course (transfer of course content to other applications).

Examples:

- spectral broadening in a femtosecond laser by self-phase modulation
- temporal measurement of ultrashort laser pulses
- compensation of imaging errors by the use of phase conjugating mirrors
- laser induced nuclear fusion
- multiphoton processes
- generation and application of higher harmonics
- optical parametric oscillators
- free-electron laser

Procurement of suitable literature/information  
 Familiarisation with new technical field of expertise  
 Use of english technical literature  
 Evaluation of available literature  
 Checking the relevance of information  
 Filtering out essential information and preparing it for the appropriate target group

**Teaching and Learning** ■ Lecture / Exercises

**Methods** ■ Seminar

**Examination Types with Weights** ■ accompanying: oral contribution [ungraded] and  
 ■ final: oral examination or (digital) written exam [100%]

**Workload** 150 Hours

**Contact Hours** 45 Hours  $\pm$  4 SWS

**Self-Study** 105 Hours

**Recommended Prerequisites** Physics: wave propagation, phase velocity  
 Laser technology: laser types, basic principle of stimulated emission  
 Light-matter interaction: absorption, scattering, refractive index, birefringence

**Mandatory Prerequisites** Seminar requires attendance in the amount of: Vortragstermine

|                                                  |                                                                                                                                                                                                                      |
|--------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"> <li>▪ Boyd – Nonlinear Optics, Elsevier</li> <li>▪ Pedrotti – Optik für Ingenieure, Springer</li> <li>▪ Saleh, Teich – Grundlagen der Photonik, Wiley VCH</li> </ul>              |
| <b>Included in Elective Catalog</b>              | <ul style="list-style-type: none"> <li>▪ SV - Studienschwerpunktmodule</li> <li>▪ WM - Allgemeiner Wahlmodulbereich</li> </ul>                                                                                       |
| <b>Included in Specialization</b>                | OT - Optische Technologien                                                                                                                                                                                           |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"> <li>▪ NLO in Master Communication Systems and Networks PO3</li> <li>▪ NLO in Master Communication Systems and Networks PO4</li> <li>▪ NLO in Master Elektrotechnik PO3</li> </ul> |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                      |
| <b>Last Update</b>                               | 19.7.2025, 14:32:16                                                                                                                                                                                                  |

## 6.24 OSA - Optische Spektroskopie und Anwendungen

|                             |                                                |
|-----------------------------|------------------------------------------------|
| <b>Module ID</b>            | OSA                                            |
| <b>Module Name</b>          | Optische Spektroskopie und Anwendungen         |
| <b>Type of Module</b>       | Elective Modules                               |
| <b>Recognized Course</b>    | OSA - Optical Spectroscopy and Applications    |
| <b>ECTS credits</b>         | 5                                              |
| <b>Language</b>             | deutsch                                        |
| <b>Duration of Module</b>   | 1 Semester                                     |
| <b>Recommended Semester</b> | 1-2                                            |
| <b>Frequency of Course</b>  | every summer term                              |
| <b>Module Coordinator</b>   | Prof. Dr. Michael Gartz/Professor Fakultät IME |
| <b>Lecturer(s)</b>          | Prof. Dr. Michael Gartz/Professor Fakultät IME |

### Learning Outcome(s)

Was: Die Studierenden können optische Messprobleme analysieren und eigene Spektrometer-Systeme synthetisieren und hinsichtlich der optischen und wirtschaftlichen Eigenschaften bewerten. Sie können Spektrometer designen, konstruieren, realisieren und damit die aus den Kundenanforderungen extrahierten Messgrößen optimal bestimmen und die Ergebnisse interpretieren.

Womit: indem die Studierenden mittels der Projektarbeit die in den Vorlesungen vermittelten Theorien anwenden, beurteilen und bewerten, mittels eigener Recherchen und Projektbesprechungen ihren Lösungsansatz entwickeln, realisieren und in eigenen Vorträgen darstellen, präsentieren und bewerten,

Wozu: um später in Entwicklungsabteilungen von optischen Messtechnikunternehmen Messprobleme zu verstehen, zu analysieren, konstruktive Lösungen zu erarbeiten und zu realisieren bis zum serienreifen Endprodukt. Um als beratende Ingenieure Kundenprobleme zu analysieren und mit am Markt befindlichen Systemen Applikationen zu erstellen, die die optischen Messprobleme lösen oder am Markt befindliche Messsysteme beurteilen und bewerten können, ob sie zur Lösung geeignet sind. Um erarbeitete oder bewertete optische Lösungen wissenschaftlich einwandfrei zu präsentieren.



**Module Contents****Lecture**

- First application
- Layer thickness measurement by optical spectroscopy
- measuring principle
- superstructure
- sensitivity
- Basics of spectroscopy
- dispersion
- angular dispersion
- linear dispersion
- prism
- Beam path in prism
- Dispersion of the prism
- diffraction grating
- Diffraction at the grating
- Dispersion at the grating
- usable spectral range of the grating
- grating types
- transmission grating
- reflection grating
- echellette grating
- concave grating
- manufacturing techniques
- scored gratings
- holographic gratings
- Diffraction efficiency of gratings
- measurement
- Blaze Technique
- Comparison: grating and prism
- Structure of spectrometers
- Structure of the monochromator
- Structure of the prism spectrometer
- resolving capacity of the prism spectrometer
- beam path
- Structure of the grating spectrometer
- resolving capacity of the grating spectrometer
- beam path
- negative effects in the spectrometer
- ghost images
- scattered light
- Second Order Effects
- radiation sources
- Properties of radiation sources
- Thermal sources
- discharge lamps
- light-emitting diodes
- laser
- Detectors / Receivers
- Properties of Receivers
- photodiode
- CCD / CMOS line / matrix
- thermal detectors
- filters
- absorption filter
- interference filters
- Calibration of spectrometers

- wavelength calibration
- intensity calibration
- Characteristics of spectrometers
  - Spectral resolution capability
  - diffraction efficiency
  - free spectral range
- Commercial spectrometers
  - UV spectrometer
  - VIS spectrometer
  - IR / NIR spectrometer
  - Multichannel Spectrometer
- Fourier spectroscopy
  - Principle of Fourier Spectroscopy
  - Fourier transform
  - Discrete Fourier transformation
  - Fourier spectrometer
- applications
  - Raman spectroscopy
  - fundamentals
  - Applications of Raman spectroscopy
  - colorimetry
  - transmission measurement
  - remission measurement
  - emission measurement
  - coating thickness measurement
  - Spectral Element Analysis
  - (further topics according to selection)
- calculate
  - the spectral resolution
  - angular and linear dispersion
  - of the free spectral range
  - the working range of the chromatic longitudinal aberration sensor
  - the resolution of the light section sensor
- select
  - a spectrometer for a special measuring task
  - a light source for absorption and transmission measurements
- determine
  - the transmission curve of various optical components
  - the spectral reflectance
  - the thickness of non-opaque layers
- assess
  - the sensitivity of a spectrometer
  - the usability of a spectrometer
- analyze
  - of measuring tasks from the field of optical spectroscopy

---

### **Project**

- Adjusting spectrometer superstructures
- record, evaluate and document optical spectra
- Check results for plausibility
- Recognizing and understanding interrelationships
- Selecting the spectrometer type for a specific measurement task

|                                                                        |
|------------------------------------------------------------------------|
| Calculation of the different spectral display modes                    |
| analyse a spectroscopic optical measuring task                         |
| Independently recognized measuring task can be analyzed                |
| a given measuring task can be analyzed                                 |
| design a solution approach for the analyzed optical measuring task     |
| Consideration of laboratory resources                                  |
| Consideration of the available time quota                              |
| Presentation of a project outline                                      |
| Describe the task                                                      |
| outline the approach                                                   |
| Present results in a clearly structured way                            |
| Discuss results in technical and scientific manner                     |
| Milestone presentation to check the progress of the project            |
| Describe the task                                                      |
| outline the approach                                                   |
| Present results in a clearly structured way                            |
| Discuss results in technical and scientific manner                     |
| Final presentation with presentation of the realized solution approach |
| Describe the task                                                      |
| outline the approach                                                   |
| Present results in a clearly structured way                            |
| Discuss results in technical and scientific manner                     |
| basic spectrometer setups can be realized by yourself                  |
| build                                                                  |
| adjust                                                                 |
| Carry out function test                                                |
| investigate scientific/technical principles with an optical structure  |
| Plan measurement series                                                |
| Estimate error influences                                              |
| Check the suitability of the superstructure                            |
| Evaluate self-acquired measurement series                              |
| Graphic display of measured values                                     |
| Calculate implicit quantities from measured values math.               |
| correctly                                                              |
| discover and name logical errors                                       |
| Simulate measured values using predefined formulas                     |
| Work on complex technical tasks in a team                              |
| Organize into subtasks                                                 |
| Discuss measurement results                                            |
| complement each other meaningfully                                     |

|                              |           |
|------------------------------|-----------|
| <b>Teaching and Learning</b> | ■ Lecture |
| <b>Methods</b>               | ■ Project |

|                                       |                                             |
|---------------------------------------|---------------------------------------------|
| <b>Examination Types with Weights</b> | ■ accompanying: project work [ungraded] and |
|                                       | ■ final: oral examination [100%]            |

|                 |           |
|-----------------|-----------|
| <b>Workload</b> | 150 Hours |
|-----------------|-----------|

|                      |                      |
|----------------------|----------------------|
| <b>Contact Hours</b> | 34 Hours $\pm$ 3 SWS |
|----------------------|----------------------|

|                   |           |
|-------------------|-----------|
| <b>Self-Study</b> | 116 Hours |
|-------------------|-----------|

|                                  |                                           |
|----------------------------------|-------------------------------------------|
| <b>Recommended Prerequisites</b> | Geometric optics                          |
|                                  | radiometry, photometry, radiation physics |
|                                  | Optical metrology                         |
|                                  | wave optics                               |
|                                  | Mathematics 1 / 2                         |
|                                  | Physics 1 / 2                             |

|                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Mandatory Prerequisites</b>                   | <ul style="list-style-type: none"><li>▪ Project requires attendance in the amount of: 3 Projektpräsentationen</li><li>▪ Participation in final examination only after successful participation in Project</li></ul>                                                                                                                                                                                                                                                                                                                          |
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"><li>▪ Demtröder, Laser-Spektroskopie, Springer</li><li>▪ Demtröder, Experimentalphysik 2, Springer</li><li>▪ Schmidt Werner, Optische Spektroskopie, Wiley-VCH</li><li>▪ Pedrotti, Pedrotti, Bausch, Schmidt, Optik für Ingenieure, Grundlagen, Springer</li><li>▪ Schröder, Treiber, Technische Optik, Vogel Verlag</li><li>▪ Hecht, Optik, Oldenbourg</li><li>▪ Bergmann, Schaefer, Bd.3, Optik, de Gruyter</li><li>▪ Max Born und Emil Wolf, Principles of Optics, Cambridge University Press</li></ul> |
| <b>Included in Elective Catalog</b>              | WM - Allgemeiner Wahlmodulbereich                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Included in Specialization</b>                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"><li>▪ OSA in Master Communication Systems and Networks PO3</li><li>▪ OSA in Master Communication Systems and Networks PO4</li><li>▪ OSA in Master Elektrotechnik PO3</li></ul>                                                                                                                                                                                                                                                                                                                             |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Last Update</b>                               | 19.7.2025, 14:32:16                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

## 6.25 PLET - Projektleitung

|                             |                                                                                                                                                              |
|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Module ID</b>            | PLET                                                                                                                                                         |
| <b>Module Name</b>          | Projektleitung                                                                                                                                               |
| <b>Type of Module</b>       | Mandatory Module                                                                                                                                             |
| <b>Recognized Course</b>    | PLET - Project management                                                                                                                                    |
| <b>ECTS credits</b>         | 5                                                                                                                                                            |
| <b>Language</b>             | deutsch                                                                                                                                                      |
| <b>Duration of Module</b>   | 1 Semester                                                                                                                                                   |
| <b>Recommended Semester</b> | 1                                                                                                                                                            |
| <b>Frequency of Course</b>  | every winter term                                                                                                                                            |
| <b>Module Coordinator</b>   | Prof. Dr. Michael Gartz/Professor Fakultät IME                                                                                                               |
| <b>Lecturer(s)</b>          | <ul style="list-style-type: none"> <li>▪ Prof. Dr. Michael Gartz/Professor Fakultät IME</li> <li>▪ Prof. Dr. Uwe Oberheide/Professor Fakultät IME</li> </ul> |

### Learning Outcome(s)

Was: Die Studierenden haben organisatorische Kompetenz erworben und können Projekt planen, durchführen, dokumentieren, Produktanforderungen analysieren, Machbarkeit bewerten und Produktqualität planen. Sie können Projektstrukturpläne und Projektzeitpläne erstellen, Projektmeilensteine planen, Projektrisiken erkennen und mildern. Sie können den Einsatz von Personal und Sachressource planen, Reviews planen, Produktverifikation planen.

Die Studierenden haben Projektführungskompetenz erworben und können die Projektsteuerung mit agilen, evolutionären Vorgehensmodellen und dem Timeboxmodell durchführen. Sie können Projektmanagementwerkzeuge einsetzen, den Projektfortschritt überwachen / steuern und Projektergebnisse freigeben. Sie können den Entwicklungsprozess fortlaufend optimieren in unklaren Situationen entscheiden. Sie können den Entwicklungsverlauf dokumentieren, Projektberichte verfassen und verteidigen.

Die Studierenden haben Personalführungskompetenz erworben und können Aufgaben auf Teammitglieder nach individuellen Qualifikationen und Neigungen verteilen.

Sie können die Teambildung fördern, das Team koordinieren und zielorientiert und respektvoll kommunizieren und verbindliche Absprachen treffen und einfordern. Sie können Teamprozesse moderieren, potenzielle Konfliktsituationen erkennen und auflösen und Handlungsalternativen abwägen.

Womit: indem sie die in dem Teamleiter Seminar erlernten Kompetenzen und Fertigkeiten und die in dem Projektleiter-Workshop erlernten Projektleitungs-Tools und Kompetenzen anwenden.

Wozu: um später in den verschiedensten Industriebereichen Projekte mittels agilen, evolutionären Vorgehensmodellen, wie z.B. SCRUM, zu planen, durchzuführen, zu managen und zum Erfolg zu bringen.

## Module Contents

### Seminar

Classifying and delimiting terms  
explain characteristic properties of development projects  
Goal orientation and innovation  
Risk of failure  
Special organisational form (teamwork)  
Limited resources  
Limited realization time  
abstractly define technical and economic goals in development projects  
abstractly define, explain and justify project management tasks  
identify and explain basic success and failure factors in project management  
unexpected technical problems  
insufficient staff qualification  
unclear or conflicting requirements  
poor project management  
Insufficient support from senior management  
identify extended challenges arising from a division of labour in project processing  
explain selected process models  
linear models for business project management  
phase model  
V-model  
agile process models for technical project management  
SCRUM  
timebox model  
classify and compare process models with regard to development duration, organizational aspects, quality and cost aspects  
professional quality control  
Cost and schedule control in business management  
Legal requirements for documentation and traceability of project decisions  
characterize basic tasks and expected results in development projects  
Planning and control of product quality  
Planning and controlling the quality of the development process  
overarching legal requirements  
industry-specific specifications  
company-internal specifications  
project risk management  
resource management  
Documentation of the development process  
Specification of the requirements for the product to be developed  
Specification of the product design  
Product development and manufacturing  
product documentation  
Verification and validation of the developed product  
Product release and product monitoring  
Characterize instruments for controlling team processes  
plan essential management tasks, milestones and project documents with regard to the course element "Project  
carry out essential management tasks mentally and identify project risks with foresight  
handle essential project management tools in a target-oriented manner  
for project (time) planning  
for requirement specifications  
Planning team building procedures, deriving expected challenges and meaningful measures

identify potential conflict situations in the team and discuss alternative actions

### Project

#### Lead team

explain to the team members the basic procedure in the project  
Capturing and classifying the competencies of team members  
agree on goals in terms of content and deadlines

#### Project management

derive requirements specification in the team from the project order  
and prioritize requirements  
Create and maintain project plan  
Identify project risks and plan meaningful mitigation measures, e.g. early feasibility studies  
Create and maintain project schedule  
Rough planning of tasks  
Plan process  
Planning effort, appointments, rooms  
Plan Project Reviews  
apply agile process model in conjunction with Timebox model to ensure a minimal project success  
Define a minimum goal that can be achieved by the team.  
define extended goals for fast teams  
Drafting a final project report  
Document and evaluate results  
Document and evaluate the project process

#### Lead team

Monitoring and controlling goal achievement  
Coordinate collaboration between team members  
Recognizing and resolving conflict situations within the team

#### Project management

Planning and managing project sections  
plan tasks for the next phase of the project in detail  
and assign them meaningfully to the team members  
Plan and moderate content reviews with team members  
Evaluate project results in the team  
Modify the project section plan and, if necessary, the project plan according to the project procedure.  
evaluate the approach of the current project phase retrospectively and, if necessary, modify it for the next project phase.  
Document project sections  
plan access to shared laboratory resources  
computer  
tools  
special workstations and measuring stations  
special test environments  
Prepare project decisions in the team

**Teaching and Learning**    ■ Seminar  
**Methods**                      ■ Project

**Examination Types with**    ■ accompanying: project work [ungraded]  
**Weights**

**Workload**                      150 Hours

**Contact Hours**              23 Hours  $\pm$  2 SWS

**Self-Study**                    127 Hours

|                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Prerequisites</b>                 | basic knowledge of project management<br>basic experience as a member of project teams                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Mandatory Prerequisites</b>                   | <ul style="list-style-type: none"><li>▪ Project requires attendance in the amount of: 8 Termine</li><li>▪ Participation in final examination only after successful participation in Project</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"><li>▪ Hans-D. Litke, „Projektmanagement, Methoden, Techniken, Verhaltensweisen, Evolutionäres Projektmanagement“, Hanser</li><li>▪ Ken Schwaber: Agiles Projektmanagement mit Scrum (Microsoft Press)</li><li>▪ Litke, Kunow, Schulz-Wimmer, „Projekt-Management“, Taschenguide , Haufe</li><li>▪ Stefan Kreiser, Skripte der Vorlesung Software Engineering f.d. Automatisierungstechnik: „Projektmanagement, Vorgehensmodelle“, ILIAS</li><li>▪ Stanley E.Portny, „Projektmanagement für Dummies“, Wiley</li><li>▪ Marcus Heidbrink, „Das Projektteam“, Haufe</li><li>▪ Video Tutorial für SCRUM: <a href="http://www.video2brain.com/de/videotraining/agile-softwareentwicklung-mit-scrum">http://www.video2brain.com/de/videotraining/agile-softwareentwicklung-mit-scrum</a></li></ul> |
| <b>Included in Elective Catalog</b>              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Included in Specialization</b>                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"><li>▪ PLET in Master Elektrotechnik PO3</li><li>▪ PLET in Master Technische Informatik PO3</li><li>▪ PLET in Master Informatik und Systems-Engineering PO1</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Last Update</b>                               | 22.8.2025, 10:17:37                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |



## 6.26 QEKS - Qualitätsgesteuerter Entwurf komplexer Softwaresysteme

|                             |                                                        |
|-----------------------------|--------------------------------------------------------|
| <b>Module ID</b>            | QEKS                                                   |
| <b>Module Name</b>          | Qualitätsgesteuerter Entwurf komplexer Softwaresysteme |
| <b>Type of Module</b>       | Elective Modules                                       |
| <b>Recognized Course</b>    | SEKM - Software Engineering by Components and Pattern  |
| <b>ECTS credits</b>         | 5                                                      |
| <b>Language</b>             | deutsch und englisch                                   |
| <b>Duration of Module</b>   | 1 Semester                                             |
| <b>Recommended Semester</b> | 1-2                                                    |
| <b>Frequency of Course</b>  | every winter term                                      |
| <b>Module Coordinator</b>   | Prof. Dr. Stefan Kreiser/Professor Fakultät IME        |
| <b>Lecturer(s)</b>          | Prof. Dr. Stefan Kreiser/Professor Fakultät IME        |

### Learning Outcome(s)

Studierende sind im Hinblick auf die Qualität eines Softwaresystems in der Lage:

- zur vorhersagbaren, effizienten Entwicklung eines Softwaresystems bzw. einer Softwarearchitektur zielgerichtet angemessene Wiederverwendungsstrategien und professionelle Modellierungs- und Entwicklungswerkzeuge sowie den Rahmenbedingungen insgesamt angemessene Projektstrukturen einzusetzen.
- die Softwarearchitektur für komplexe, verteilte Automatisierungssysteme unter Berücksichtigung der spezifischen Anforderungen hinsichtlich der besonderen Zielsetzung des jeweiligen Automatisierungssystems zu analysieren, zu konzipieren, zu entwerfen, zu implementieren, zu prüfen und zu bewerten.
- die besonderen Anforderungen an die Servicequalität, an die Einsatzumgebung und die organisatorischen Rahmenbedingungen für die Entwicklung, die sich aus dem Entwicklungsprozess und einem angemessenen Lebenszyklusmanagement ergeben, zu erkennen und im Hinblick auf ihre Relevanz für die Softwarearchitektur des Automatisierungssystems zu analysieren und zu bewerten.

**Module Contents****Lecture / Exercises**

Terminology  
value vs. cost of a technical software  
distributed software system, concurrency  
software quality, quality of service, refactoring  
complexity (algorithmic, structural), emergence  
re-use, symmetry and symmetry operations, abstraction, invariants  
quality controlled re-use, methodical approaches  
variants of white box re-use  
black box re-use  
grey box re-use (hierarchical approach to re-use)  
re-use in automation control software systems  
determinism  
benefits and challenges  
tailoring process models and personnel structures in projects  
meet requirements in development projects predictably (product quality, cost, deadlines)  
distributed development, maintenance and support of software systems  
software pattern  
pattern description using UML  
essential architectural pattern  
construction pattern  
structural pattern  
behavioural pattern  
class based (static) vs. object based (dynamic) pattern  
essential pattern for concurrent and networked real time systems  
encapsulation and role based extension of layered architectures  
concurrency structures to optimize throughput and system response latency  
distributed event processing  
process synchronisation  
construction and use of pattern catalogues, pattern languages  
pattern based design of complex software systems  
components and frameworks  
design principles  
interface architecture  
active and passive system elements  
design, programming and test  
quality  
configuration and use  
using middleware systems to develop architectures of technical software systems  
ORB architectures, e.g. CORBA and TAO  
integrated system platforms, e.g. MS .NET  
multi agent systems (MAS)  
agent architectural models  
collaboration between agents  
agent languages  
considering cases for MAS application

use pattern to design complex software systems  
extract and discuss purpose, limitation of use, invariant and configurable parts of pattern from english and german literature sources  
understand implementation skeletons of pattern and map them to problem settings with limited technical focus  
discuss benefits of using object oriented programming languages  
derive recurrent settings in the development of complex software systems  
implement pattern on exemplary settings and test resulting implementations  
reasonably combine pattern to solve recurring problem settings with a broader technical focus  
use UML2 notations  
use professional UML2 IDE for round-trip-engineering  
integrate software system based on exemplary implementations of the pattern to combine  
conduct integration test, assess software quality and optimize software system

construct black-box-components based on pattern  
analyse component based software architectures  
derive suitable scope from architectural specs  
understand and discuss development process to construct software systems  
find active and passive system elements and derive system run time behaviour  
understand abstract system interfaces to interconnect, configure and activate components  
understand abstract system interfaces to exchange applicational run time data  
understand system extension points (functional and structural system configuration layer)  
analyse distribution architectures  
understand basic system services (describe and reason service usage, relate to system tasks)  
relate pattern to structure making architectural software artefacts  
derive suitable range of applications for a given distribution architecture  
understand engineering process to construct user applications (application layer)  
discuss attributes and limitation of usage of interconnection protocols  
find designated system extension points  
compare MAS to conventional distribution architectures  
agent vs. component  
architectural models  
activation of agents  
deployment of agents  
protocols for interconnection and collaboration  
range of applications and and limitation of usage

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### **Seminar**

challenging seminar topics can be defined e.g. from the following or related subject areas

- reusable artifacts for building the architecture of distributed software systems,
- professional distribution architectures,
- Multiagent systems,
- special economic, liability and ethical requirements for software systems with (distributed) artificial intelligence and their effects on the design of software architectures

present personal work results and work results of the team in a compact and target-group-oriented way, both orally and in writing

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### **Project**

Develop software artifact of a distribution architecture for complex software systems  
Carry out project planning in distributed teams with an agile process model  
Perform extensive system analysis with respect to the role of the artifact in the distribution architecture  
Determine design input requirements for the development of the artifact  
Specify and model the software artifact based on the design input requirements  
Select and justify design principles and patterns to achieve defined quality objectives  
Derive interfaces, behavioral and structural models iteratively based on patterns in UML2 notations  
Use professional UML2 design tool purposefully  
Verify and evaluate models, correct model errors and optimize models  
Programming software artifacts in C++  
define meaningful test scenarios and verify software artifacts  
Evaluate the quality of the software artifact  
Present the team's project results to a professional audience in a compact and target-group-oriented way

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|                                      |                                                                                                           |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------|
| <b>Teaching and Learning Methods</b> | <ul style="list-style-type: none"><li>▪ Lecture / Exercises</li><li>▪ Seminar</li><li>▪ Project</li></ul> |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------|

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|                                       |                                                                                                                                      |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| <b>Examination Types with Weights</b> | <ul style="list-style-type: none"><li>▪ accompanying: project work [ungraded] and</li><li>▪ final: oral examination [100%]</li></ul> |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|

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|                 |           |
|-----------------|-----------|
| <b>Workload</b> | 150 Hours |
|-----------------|-----------|

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|                      |                      |
|----------------------|----------------------|
| <b>Contact Hours</b> | 57 Hours $\pm$ 5 SWS |
|----------------------|----------------------|

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|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Self-Study</b>                                | 93 Hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Recommended Prerequisites</b>                 | <ul style="list-style-type: none"> <li>▪ Modul PLET: oder aus einem (naturwissenschaftlich-technischen) Bachelorstudium: - grundlegende Kenntnisse in (agilem) Projektmanagement</li> <li>▪ - programming skills in an object-oriented programming language, preferably C++</li> <li>▪ - knowledge of software modeling using Unified Modeling Language (UML) or other (formal) languages that support modeling of interfaces, behavior and structures</li> <li>▪ - basic knowledge in (agile) project management, SCRUM oder XP</li> <li>▪ - basic knowledge of essential software architectural models</li> <li>▪ - basic knowledge of interconnection models in software systems (OSI, TCP/IP, Messaging)</li> </ul>                                                                                                                                                                                                                                                                                                   |
| <b>Mandatory Prerequisites</b>                   | <ul style="list-style-type: none"> <li>▪ Project requires attendance in the amount of: 3 Termine</li> <li>▪ Participation in final examination only after successful participation in Project</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"> <li>▪ D. Schmidt et.al.: Pattern-Oriented Software Architecture. Patterns for Concurrent and Networked Objects (Wiley)</li> <li>▪ Gamma et.al.: Design Patterns, (Addison-Wesley)</li> <li>▪ Martin Fowler: Refactoring, Engl. ed. (Addison-Wesley Professional)</li> <li>▪ U. Hammerschall: Verteilte Systeme und Anwendungen (Pearson Studium)</li> <li>▪ Andreas Andresen: Komponentenbasierte Softwareentwicklung m. MDA, UML2, XML (Hanser Verlag)</li> <li>▪ T. Ritter et. al.: CORBA Komponenten. Effektives Software-Design u. Progr. (Springer)</li> <li>▪ Bernd Oestereich: Analyse und Design mit UML 2.5 (Oldenbourg)</li> <li>▪ OMG Unified Modeling Language Spec., <a href="http://www.omg.org/um">www.omg.org/um</a></li> <li>▪ I. Sommerville: Software Engineering (Addison-Wesley / Pearson Studium)</li> <li>▪ K. Beck: eXtreme Programming (Addison-Wesley Professional)</li> <li>▪ Ken Schwaber: Agiles Projektmanagement mit Scrum (Microsoft Press)</li> </ul> |
| <b>Included in Elective Catalog</b>              | <ul style="list-style-type: none"> <li>▪ SV - Studienschwerpunktmodule</li> <li>▪ WM - Allgemeiner Wahlmodulbereich</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Included in Specialization</b>                | AU - Automatisierungstechnik                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"> <li>▪ QEKS in Master Communication Systems and Networks PO3</li> <li>▪ QEKS in Master Communication Systems and Networks PO4</li> <li>▪ QEKS in Master Elektrotechnik PO3</li> <li>▪ QEKS in Master Technische Informatik PO3</li> <li>▪ QEKS in Master Informatik und Systems-Engineering PO1</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Last Update</b>                               | 19.7.2025, 14:32:16                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

## 6.27 QM - Quantenmechanik

|                             |                                                |
|-----------------------------|------------------------------------------------|
| <b>Module ID</b>            | QM                                             |
| <b>Module Name</b>          | Quantenmechanik                                |
| <b>Type of Module</b>       | Elective Modules                               |
| <b>Recognized Course</b>    | QM - Quantum mechanics                         |
| <b>ECTS credits</b>         | 5                                              |
| <b>Language</b>             | deutsch                                        |
| <b>Duration of Module</b>   | 1 Semester                                     |
| <b>Recommended Semester</b> | 1-2                                            |
| <b>Frequency of Course</b>  | every winter term                              |
| <b>Module Coordinator</b>   | Prof. Dr. Uwe Oberheide/Professor Fakultät IME |
| <b>Lecturer(s)</b>          | Prof. Dr. Uwe Oberheide/Professor Fakultät IME |

### Learning Outcome(s)

Die Studierenden besitzen ein Verständnis der Grundlagen quantenmechanischer Prozesse, indem sie anhand klassisch nicht erklärbarer Experimente die Entwicklung der Quantentheorie nachvollziehen und einfache, analytisch auswertbare Anwendungsfälle mathematisch beschreiben und auf reale Anwendungen der Elektrotechnik und Optik überführen, um in zukünftigen technischen Entwicklungen und Technologiefeldern Herausforderungen und Grenzen der Systeme einschätzen sowie wesentliche Strukturen im interdisziplinären Diskurs verstehen zu können.

### Module Contents

#### Lecture

The failure of classical physics (black spot, photoelectric effect, Compton effect, Stern-Gerlach experiment, Bohr's atom model, matter waves)

Quantum behaviour (experiments with spheres, waves and electrons; basic principles of quantum mechanics; principle of indeterminacy; laws of combination of amplitudes; identical particles)

Schrödinger equation (development of the wave equation; stationary, time-dependent)

simple potential problems (infinitely deep potential pot, finitely deep potential pot, potential stage, potential barrier, harmonic oscillator, hydrogen atom)

Basic principles of quantum computers and quantum cryptography

Description of given physical problems mathematically by listing the Schrödinger equation and applying of methods to solve the differential equations (separation approaches, limit value considerations)

To evaluate physical solutions and select them by analogy

Analyzing quantum effects and transferring them to technical applications

#### Seminar

Discourse on quantum mechanical processes (uncertainty principle, wave-particle dualism, wave functions/packages) and their applications in real systems in the context of the course

|                                      |                                                                                |
|--------------------------------------|--------------------------------------------------------------------------------|
| <b>Teaching and Learning Methods</b> | <ul style="list-style-type: none"> <li>▪ Lecture</li> <li>▪ Seminar</li> </ul> |
|--------------------------------------|--------------------------------------------------------------------------------|

|                                       |                                                                                                                                       |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| <b>Examination Types with Weights</b> | <ul style="list-style-type: none"> <li>▪ accompanying: term paper [ungraded] and</li> <li>▪ final: oral examination [100%]</li> </ul> |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|

|                 |           |
|-----------------|-----------|
| <b>Workload</b> | 150 Hours |
|-----------------|-----------|

|                      |                      |
|----------------------|----------------------|
| <b>Contact Hours</b> | 34 Hours $\pm$ 3 SWS |
|----------------------|----------------------|

|                   |           |
|-------------------|-----------|
| <b>Self-Study</b> | 116 Hours |
|-------------------|-----------|

|                                                  |                                                                                                                                                                                                                                                                                                                     |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Prerequisites</b>                 | In-depth knowledge of mathematics (integral calculus, differential calculus, vector geometry)<br>Basic knowledge of physics (oscillations and waves, double slit, interference, thermodynamics, potential / kinetic energy)<br>Basic knowledge of electrical engineering (magnetic and electric fields, components) |
| <b>Mandatory Prerequisites</b>                   |                                                                                                                                                                                                                                                                                                                     |
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"><li>▪ Harris – Moderne Physik, Pearson Verlag</li><li>▪ Feynman - Vorlesungen über Physik Band III:Quantenmechanik, Oldenbourg Verlag</li></ul>                                                                                                                                   |
| <b>Included in Elective Catalog</b>              | <ul style="list-style-type: none"><li>▪ SV - Studienschwerpunktmodule</li><li>▪ WM - Allgemeiner Wahlmodulbereich</li></ul>                                                                                                                                                                                         |
| <b>Included in Specialization</b>                | OT - Optische Technologien                                                                                                                                                                                                                                                                                          |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"><li>▪ QM in Master Elektrotechnik PO3</li><li>▪ QM in Master Technische Informatik PO3</li><li>▪ QM in Master Informatik und Systems-Engineering PO1</li></ul>                                                                                                                    |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                                                                                                                     |
| <b>Last Update</b>                               | 19.7.2025, 14:32:16                                                                                                                                                                                                                                                                                                 |

## 6.28 RA - Reflexion Auslandssemester

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| <b>Module ID</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | RA                                                                                                               |
| <b>Module Name</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Reflexion Auslandssemester                                                                                       |
| <b>Type of Module</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Elective Modules                                                                                                 |
| <b>Recognized Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | RA - Reflection on the semester abroad                                                                           |
| <b>ECTS credits</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 6                                                                                                                |
| <b>Language</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | deutsch, englisch bei Bedarf                                                                                     |
| <b>Duration of Module</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 1 Semester                                                                                                       |
| <b>Recommended Semester</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 1-2                                                                                                              |
| <b>Frequency of Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | every term                                                                                                       |
| <b>Module Coordinator</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Studiengangsleiter(in) Master Technische Informatik / Informatik und Systems-Engineering                         |
| <b>Lecturer(s)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | verschiedene Dozenten*innen / diverse lecturers                                                                  |
| <b>Learning Outcome(s)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                  |
| <p>Die Studierenden reflektieren kulturelle, gesellschaftliche und strukturelle Gemeinsamkeiten und Unterschiede ihrer Heimathochschule/-land und der Gasthochschule/-land. Sie werden dadurch in die Lage versetzt, bewusste Entscheidungen hinsichtlich ihrer zukünftigen akademischen und beruflichen Mobilität zu treffen.</p> <p>Die Studierenden reflektieren die persönlichen Erfahrungen, die sie während ihres Auslandssemesters gemacht haben, um ihr allgemeines Wertebewusstsein kritisch zu hinterfragen und ggf. zu justieren.</p> |                                                                                                                  |
| <b>Module Contents</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                  |
| <b>Seminar</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                  |
| <p>Students are able to reflect on cultural, social and structural similarities and differences between their home university/country and the host university/country. This enables them to make informed decisions regarding their future academic and professional mobility.</p> <p>Students can reflect on the personal experiences they have had during their semester abroad in order to critically question and, if necessary, adjust their general awareness of values.</p>                                                               |                                                                                                                  |
| <b>Teaching and Learning Methods</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Seminar                                                                                                          |
| <b>Examination Types with Weights</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | ▪ accompanying: oral contribution or term paper or learning portfolio [ungraded]                                 |
| <b>Workload</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 180 Hours                                                                                                        |
| <b>Contact Hours</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 12 Hours $\pm$ 1 SWS                                                                                             |
| <b>Self-Study</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 168 Hours                                                                                                        |
| <b>Recommended Prerequisites</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | As a rule, a one-semester or longer period of study at a foreign university is a prerequisite for participation. |
| <b>Mandatory Prerequisites</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Seminar requires attendance in the amount of: 1 Termin                                                           |
| <b>Recommended Literature</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                  |
| <b>Included in Elective Catalog</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                  |
| <b>Included in Specialization</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                  |

|                                                  |                                                                                                                                                                                                                                                                                                                                                                                                     |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"><li>▪ RA in Bachelor Elektrotechnik und Informationstechnik PO1</li><li>▪ RA in Bachelor Medientechnologie PO4</li><li>▪ RA in Bachelor Informatik und Systems-Engineering PO1</li><li>▪ RA in Master Communication Systems and Networks PO4</li><li>▪ RA in Master Medientechnologie PO4</li><li>▪ RA in Master Informatik und Systems-Engineering PO1</li></ul> |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                            |                                                                                    |
|----------------------------|------------------------------------------------------------------------------------|
| <b>Specifics and Notes</b> | This course is aimed exclusively at students who have completed a semester abroad. |
|----------------------------|------------------------------------------------------------------------------------|

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|--------------------|---------------------|
| <b>Last Update</b> | 19.7.2025, 14:32:16 |
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## 6.29 RFSD - RF System Design

|                             |                                                    |
|-----------------------------|----------------------------------------------------|
| <b>Module ID</b>            | RFSD                                               |
| <b>Module Name</b>          | RF System Design                                   |
| <b>Type of Module</b>       | Elective Modules                                   |
| <b>Recognized Course</b>    | RFSD - RF System Design                            |
| <b>ECTS credits</b>         | 5                                                  |
| <b>Language</b>             | englisch                                           |
| <b>Duration of Module</b>   | 1 Semester                                         |
| <b>Recommended Semester</b> | 1-2                                                |
| <b>Frequency of Course</b>  | every winter term                                  |
| <b>Module Coordinator</b>   | Prof. Dr. Rainer Kronberger/Professor Fakultät IME |
| <b>Lecturer(s)</b>          | Prof. Dr. Rainer Kronberger/Professor Fakultät IME |

### Learning Outcome(s)

In general: Students will learn how high frequency components of wireless communication systems work

Module-specific:

students will get a general introduction in rf systems

they will learn in detail how transmitters and receivers in wireless communication systems work

they will learn in detail how the components of such systems (LNA, mixer, amplifier, oscillator, etc.) work

they will learn about limitation effects and noise in such systems

they will learn how to adapt the components to each other and how to plan and design the complete system (transmitter and / or receiver)

### Module Contents

#### Lecture / Exercises

RF System, Applications

Noise in RF systems

noise classification and characterization

noise calculation

noise figure

noise matching

Linear and nonlinear circuit behaviour

theory

nonlinearities with mixers

nonlinearities with amplifiers

RF system components

receiver components

transmitter components

frequency generation

#### Lab

|                                      |                                                                                        |
|--------------------------------------|----------------------------------------------------------------------------------------|
| <b>Teaching and Learning Methods</b> | <ul style="list-style-type: none"> <li>▪ Lecture / Exercises</li> <li>▪ Lab</li> </ul> |
|--------------------------------------|----------------------------------------------------------------------------------------|

|                                       |                                                                                                                                                                   |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Examination Types with Weights</b> | <ul style="list-style-type: none"> <li>▪ accompanying: exercise lab [ungraded] and</li> <li>▪ final: (digital) written exam or oral examination [100%]</li> </ul> |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                 |           |
|-----------------|-----------|
| <b>Workload</b> | 150 Hours |
|-----------------|-----------|

|                      |                      |
|----------------------|----------------------|
| <b>Contact Hours</b> | 45 Hours $\pm$ 4 SWS |
|----------------------|----------------------|

|                                                  |                                                                                                                                                                                                                                                                                                                                           |
|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Self-Study</b>                                | 105 Hours                                                                                                                                                                                                                                                                                                                                 |
| <b>Recommended Prerequisites</b>                 | No formal requirements, but students should have knowledge in High Frequency and Microwave Topics                                                                                                                                                                                                                                         |
| <b>Mandatory Prerequisites</b>                   | <ul style="list-style-type: none"><li>▪ Participation in final examination only after successful participation in Lecture / Exercises</li><li>▪ Lab requires attendance in the amount of: 3 Labortermine und 1 Präsentationstermin</li><li>▪ Participation in final examination only after successful participation in Lab</li></ul>      |
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"><li>▪ Kraus &amp; Carver Eletromagnetics, McGraw Hill, 2006.</li><li>▪ Michale Steer, Microwave and RF Design</li></ul>                                                                                                                                                                                 |
| <b>Included in Elective Catalog</b>              | WM - Allgemeiner Wahlmodulbereich                                                                                                                                                                                                                                                                                                         |
| <b>Included in Specialization</b>                |                                                                                                                                                                                                                                                                                                                                           |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"><li>▪ RFSD in Master Communication Systems and Networks PO3</li><li>▪ RFSD in Master Communication Systems and Networks PO4</li><li>▪ RFSD in Master Medientechnologie PO4</li><li>▪ RFSD in Master Technische Informatik PO3</li><li>▪ RFSD in Master Informatik und Systems-Engineering PO1</li></ul> |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                                                                                                                                           |
| <b>Last Update</b>                               | 19.7.2025, 14:32:16                                                                                                                                                                                                                                                                                                                       |

### 6.30 RM - Rastermikroskopie

|                             |                                                  |
|-----------------------------|--------------------------------------------------|
| <b>Module ID</b>            | RM                                               |
| <b>Module Name</b>          | Rastermikroskopie                                |
| <b>Type of Module</b>       | Elective Modules                                 |
| <b>Recognized Course</b>    | RM - Scanning Microscopy                         |
| <b>ECTS credits</b>         | 5                                                |
| <b>Language</b>             | deutsch                                          |
| <b>Duration of Module</b>   | 1 Semester                                       |
| <b>Recommended Semester</b> | 1-2                                              |
| <b>Frequency of Course</b>  | every winter term                                |
| <b>Module Coordinator</b>   | Prof. Dr. Stefan Altmeyer/Professor Fakultät IME |
| <b>Lecturer(s)</b>          | Prof. Dr. Stefan Altmeyer/Professor Fakultät IME |

#### Learning Outcome(s)

Was:

Das Modul vermittelt vertieftes MINT- und studiengangsspezifisches Fachwissen (K5, K6), schult sie Abstraktionsfähigkeit, Analysefähigkeit und sowie die Fähigkeit zur Bewertung komplexes Systeme (K7, K8, K9).

Vorlesungsbegleitend findet ein projektnahes Praktikum statt. Situations- und sachgerechtes argumentieren (K12) wird durch die Praktikumsgespräche geübt. Die eigenständige Bearbeitung komplexer wissenschaftlicher Aufgaben (K10) und die Projektorganisation (K13) wird ebenso trainiert

Womit:

Der Dozent vermittelt das vertieftem MINT- und einschlägigem Fachwissen in einer Vorlesung mit integrierten kurzen Übungsteilen und einem dedizierten Freiraum für fachliche Diskussionen, um Sprachgebrauch und Ausdrucksfähigkeit zu schulen und auf den wissenschaftlichen Diskurs vorzubereiten.

Weiterhin wird das Praktikum gezielt projektartig durchgeführt und wird wie ein kleiner Forschungsauftrag verstanden. Die Praktikumsaufgaben sind in Ihrer Fragestellung zunächst weit gefasst sind, müssen von den Studierenden selber konkretisiert werden und können dann mit einer weit reichenden zeitlichen Flexibilität abgearbeitet werden. Dazu erhalten die Studierenden zu jeder Zeit der Laboröffnungszeiten Zugang zu der Geräteausstattung. Begleitet wird das Praktikum von regelmäßigen, wissenschaftlichen Diskussionen.

Wozu:

Vorbereitung auf eine selbständige, forschende Tätigkeit, sowohl fachlich als auch organisatorisch. (HF1)

Anwendung tiefgreifende Fachkenntnisse im Bereich höchstauflösender Mess- und Analyseverfahren, die industriell als Mess- und Prüftechnologie zur Qualitätskontrolle von Produkten (HF2) eingesetzt werden, sowie Kompetenzvermittlung im Bereich der Überwachung von Produktionsprozessen (HF3)

**Module Contents****Lecture / Exercises**

electron microscopy  
wave-particle dualism of electrons, De Broglie wavelength  
relativistic mass increase  
resolution of electron optical systems  
depth of field in an electron microscope  
electron emission  
physics of electron emission  
thermoionic emission  
Schottky emission  
field emission  
technical construction of electron emitters  
brightness as a conserving magnitude  
magnetic deflection units  
focussing lens  
equations of motion for electrons in focussing lenses  
principles of aberration minimization  
scan system  
electron matter interaction  
primary electrons  
secondary electrons  
Auger electrons  
Bremsstrahlung  
characteristic x rays  
cathodo luminescence  
Everhart-Thornley detector  
electron contrast  
topography contrast  
material contrast  
lattice orientation contrast  
conductivity contrast  
applications and limitations

tunneling microscope  
wave function  
definition  
continuity and continuous differentiable  
probability interpretation  
principle  
potential diagram  
Fermi level  
work function  
quantummechanical calculation of the tunneling probability  
biased tunneling barrier and WKB approximation  
piezo motors  
physical principles  
nonlinearity, hysteresis, creep  
principles of control theory in a tunneling microscope  
preparation of tunneling tips  
image as result of a measurement  
convolution of object and tip  
lattice resolution and atomic resolution  
applications and limits

atomic force microscope  
setup

types: contact mode, noncontact mode, tapping mode, magnetic mode,  
applications and limits

confocal microscopy  
principle of confocal apertures  
principle of optical sectioning  
lateral and axial resolution  
pupil illumination and over-illumination in confocal laser scanning microscopes  
problems of adjustment  
Nipkow disc  
freedom of adjustment  
light budget and reflections  
rotating microlens array  
confocal dispersion sensor  
applications and limits

electron microscope  
calculate classical and relativistic electron speeds  
calculate wavelengths of electron  
calculate resolution of electron optical systems  
explain the different emission regimes  
explain the different electron-matter interaction processes  
sketch and explain the different types of electron lenses  
sketch and explain an Everhart-Thornley detector  
calculate the depth of field in an electron microscope

tunneling microscope  
sketch and explain the potential over space diagram for tunneling  
explain the Ansatz to calculate the tunneling probability  
explain the difference between atomic- and lattice resolution

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### Lab

Adjustment and use of  
electron microscopes  
tunneling microscopes  
atomic force microscopes  
confocal microscopes

perform a metrological task  
measurement of heights  
measurement of 3D topographies  
structural analysis  
finding ultimate resolution limits

interpretation of metrological findings

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|                              |                       |
|------------------------------|-----------------------|
| <b>Teaching and Learning</b> | ▪ Lecture / Exercises |
| <b>Methods</b>               | ▪ Lab                 |

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|                                       |                                                                                 |
|---------------------------------------|---------------------------------------------------------------------------------|
| <b>Examination Types with Weights</b> | ▪ accompanying: exercise lab [ungraded] and<br>▪ final: oral examination [100%] |
|---------------------------------------|---------------------------------------------------------------------------------|

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|                 |           |
|-----------------|-----------|
| <b>Workload</b> | 150 Hours |
|-----------------|-----------|

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|                      |                             |
|----------------------|-----------------------------|
| <b>Contact Hours</b> | 45 Hours $\triangleq$ 4 SWS |
|----------------------|-----------------------------|

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|                   |           |
|-------------------|-----------|
| <b>Self-Study</b> | 105 Hours |
|-------------------|-----------|

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|                                                  |                                                                                                                                                                                                                                                                         |
|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Prerequisites</b>                 | mathematics:<br>differential- and integral calculus<br>complex numbers<br>vector calculus<br>basics of differential geometry<br><br>physics / optics:<br>geometrical optics<br>wave optics                                                                              |
| <b>Mandatory Prerequisites</b>                   | <ul style="list-style-type: none"><li>▪ Lab requires attendance in the amount of: 5 Labortermine</li><li>▪ Participation in final examination only after successful participation in Lab</li></ul>                                                                      |
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"><li>▪ Reimer: Scanning Electron Microscopy (Springer)</li><li>▪ Meyer, Hug, Bennewitz: Scanning Probe Microscopy (Springer)</li><li>▪ Wilhelm, Gröbler, Gluch, Heinz: Die konfokale Laser Scanning Mikroskopie (Carl Zeiss)</li></ul> |
| <b>Included in Elective Catalog</b>              | WM - Allgemeiner Wahlmodulbereich                                                                                                                                                                                                                                       |
| <b>Included in Specialization</b>                |                                                                                                                                                                                                                                                                         |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"><li>▪ RM in Master Communication Systems and Networks PO3</li><li>▪ RM in Master Communication Systems and Networks PO4</li><li>▪ RM in Master Elektrotechnik PO3</li></ul>                                                           |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                                                                         |
| <b>Last Update</b>                               | 19.7.2025, 14:32:16                                                                                                                                                                                                                                                     |

### 6.31 SIM - Simulation in der Ingenieurwissenschaft

|                             |                                                       |
|-----------------------------|-------------------------------------------------------|
| <b>Module ID</b>            | SIM                                                   |
| <b>Module Name</b>          | Simulation in der Ingenieurwissenschaft               |
| <b>Type of Module</b>       | Mandatory Module                                      |
| <b>Recognized Course</b>    | FEM - Finite element method in electrical engineering |
| <b>ECTS credits</b>         | 5                                                     |
| <b>Language</b>             | deutsch                                               |
| <b>Duration of Module</b>   | 1 Semester                                            |
| <b>Recommended Semester</b> | 2                                                     |
| <b>Frequency of Course</b>  | every summer term                                     |
| <b>Module Coordinator</b>   | Prof. Dr. Wolfgang Evers/Professor Fakultät IME       |
| <b>Lecturer(s)</b>          | Prof. Dr. Wolfgang Evers/Professor Fakultät IME       |

#### Learning Outcome(s)

Die Studierenden können technische Systeme mit Hilfe von rechnergestützten, numerischen Simulationen berechnen, indem sie Modelle der realen Systeme bilden, diese als Modelle in einem Simulationsprogramm erstellen und unter den gewünschten Randbedingungen die Berechnungen durchführen und auswerten um später bei Entwicklungsaufgaben das Verhalten von zu entwickelnden Produkten im Voraus bestimmen und optimieren können.

#### Module Contents

##### Lecture / Exercises

Discretisation of physical problems using the example of an electrostatic arrangement

- One-dimensional model
- Two-dimensional model
- Replacement of partial derivatives by finite differences
- Boundary conditions
- Setting up the linear system of equations
- Different methods for solving the system of equations
- Result representation with interpolation
- Use of boundary-fitted grids
- Solving a two-dimensional electrostatic problem with FEM software
- Exploiting symmetries in the simulation
- Solving a two-dimensional magnetic problem with FEM software
- Extending the magnetic problem to include non-linear material properties
- Extension of the simulation by program-controlled variation of parameters and automatic output of characteristic diagrams with Python

Carry out and critically evaluate FEM simulations on various physical effects

##### Project

|                                      |                                                                                            |
|--------------------------------------|--------------------------------------------------------------------------------------------|
| <b>Teaching and Learning Methods</b> | <ul style="list-style-type: none"> <li>▪ Lecture / Exercises</li> <li>▪ Project</li> </ul> |
|--------------------------------------|--------------------------------------------------------------------------------------------|

|                                       |                                                                                       |
|---------------------------------------|---------------------------------------------------------------------------------------|
| <b>Examination Types with Weights</b> | <ul style="list-style-type: none"> <li>▪ accompanying: project work [100%]</li> </ul> |
|---------------------------------------|---------------------------------------------------------------------------------------|

|                 |           |
|-----------------|-----------|
| <b>Workload</b> | 150 Hours |
|-----------------|-----------|

|                      |                      |
|----------------------|----------------------|
| <b>Contact Hours</b> | 45 Hours $\pm$ 4 SWS |
|----------------------|----------------------|

|                   |           |
|-------------------|-----------|
| <b>Self-Study</b> | 105 Hours |
|-------------------|-----------|

|                                  |                                                                                                                                                          |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Prerequisites</b> | - Electrostatic: field strength, flux density, dielectrics<br>- Electromagnetism: field strength, flux density, flux, magnetic circuits, induced voltage |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|

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**Mandatory Prerequisites**

|                               |                                                                                                     |
|-------------------------------|-----------------------------------------------------------------------------------------------------|
| <b>Recommended Literature</b> | ■ Thomas Westermann, Modellbildung und Simulation<br>■ Thomas Westermann: Mathematik für Ingenieure |
|-------------------------------|-----------------------------------------------------------------------------------------------------|

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**Included in Elective Catalog**

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**Included in Specialization**

|                                                  |                                                                                                                                                                                                                                                               |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Use of the Module in Other Study Programs</b> | ■ SIM in Master Communication Systems and Networks PO3<br>■ SIM in Master Communication Systems and Networks PO4<br>■ SIM in Master Elektrotechnik PO3<br>■ SIM in Master Technische Informatik PO3<br>■ SIM in Master Informatik und Systems-Engineering PO1 |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

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**Specifics and Notes**

|                    |                     |
|--------------------|---------------------|
| <b>Last Update</b> | 19.7.2025, 14:32:16 |
|--------------------|---------------------|



### 6.32 SNEE - Stromnetze für erneuerbare Energien

|                             |                                                         |
|-----------------------------|---------------------------------------------------------|
| <b>Module ID</b>            | SNEE                                                    |
| <b>Module Name</b>          | Stromnetze für erneuerbare Energien                     |
| <b>Type of Module</b>       | Elective Modules                                        |
| <b>Recognized Course</b>    | SNEE - Electrical Power Grids for Renewable Energy      |
| <b>ECTS credits</b>         | 5                                                       |
| <b>Language</b>             | deutsch, englisch bei Bedarf                            |
| <b>Duration of Module</b>   | 1 Semester                                              |
| <b>Recommended Semester</b> | 1-2                                                     |
| <b>Frequency of Course</b>  | every summer term                                       |
| <b>Module Coordinator</b>   | Prof. Dr. Eberhard Waffenschmidt/Professor Fakultät IME |
| <b>Lecturer(s)</b>          | Prof. Dr. Eberhard Waffenschmidt/Professor Fakultät IME |

#### Learning Outcome(s)

Vor dem Hintergrund einer klima- und ressourcenschonenden Energiewende stehen unsere Stromnetze vor einem fundamentalen Wandel, der sich in den Zielen dieses Moduls widerspiegelt.

WAS: Die Studierenden erkennen die größten Herausforderungen an die elektrischen Verteilnetze und erarbeiten und bewerten Lösungsvorschläge.

WOMIT: Sie benennen die verschiedenen Netzformen, Komponenten und verwenden Fachbegriffe der elektrischen Netze. Sie berücksichtigen ihre Kenntnis der relevanten technischen und rechtlichen Vorgaben beim Anschluss von dezentralen Einspeisern an das Stromnetz. Sie kennen die verschiedenen Berechnungs-Methoden zur Analyse von elektrischen Netzen und wenden anwendungsbezogen die passende Methode an. Sie berücksichtigen die Grundlagen zur Steuerung und Regelung von elektrischen Netzen beim Einsatz von regelungstechnischen Berechnungsmethoden.

Aufbauend auf diesen Kompetenzen erstellen sie in Arbeitsgruppen Simulationsmodelle von elektrischen Netzen. Sie analysieren die Simulationsergebnisse anhand von vermittelten Rahmenbedingungen und bewerten die Ergebnisse anhand der selbst vorgegeben Ziele.

WOZU: Sie können später beurteilen, ob Stromnetze eines Netzbetreibers den zukünftigen Anforderungen genügen und sind in der Lage, einen sachgerechten Ausbau zu planen. Ferner können sie beurteilen, ob oder unter welchen Umständen ein Netzanschluss von dezentralen Einspeisern oder größeren Lasten möglich ist.

**Module Contents****Lecture**

- The students name different grid topologies, components and are able to use terms related to electrical power grids.
  - They consider their knowledge of relevant technical and legal requirements for the connection of decentralized generators to the power grid.
  - They know different calculation methods for the analysis of electrical power grids and apply the suitable method for a particular problem.
  - They consider the basics for the control of electrical power grids using suitable control methods.
  - Summarizing it includes the following topics:
    - Grid topologies and components
    - Calculation and simulation of power grid
    - Fault management
    - Grid control
    - Gridconnection of decentralized generators
- Based on these competencies the students perform project works (see "Projektarbeit").

**Project**

Based on the knowledge of the lectures the students perform a project. They create simulation models of electrical power grids working in teams of 3 to 4 persons. They analyze the simulation results according to frame conditions and evaluate the results along self generated goals.

Project topics are:

Future loads of electrical power grids due to

- Photovoltaics
- Electromobility
- Electrical heat usage
- Electrical heat storages

under different requirements as e.g. settlement areas

- city
- suburban
- rural

The project work is performed during the presence time with moderation of the lecturer and as homework.

|                                      |                                                                             |
|--------------------------------------|-----------------------------------------------------------------------------|
| <b>Teaching and Learning Methods</b> | <ul style="list-style-type: none"><li>▪ Lecture</li><li>▪ Project</li></ul> |
|--------------------------------------|-----------------------------------------------------------------------------|

|                                       |                                                                                                                                |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| <b>Examination Types with Weights</b> | <ul style="list-style-type: none"><li>▪ accompanying: project work [60%] and</li><li>▪ final: oral examination [40%]</li></ul> |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|

|                 |           |
|-----------------|-----------|
| <b>Workload</b> | 150 Hours |
|-----------------|-----------|

|                      |                      |
|----------------------|----------------------|
| <b>Contact Hours</b> | 34 Hours $\pm$ 3 SWS |
|----------------------|----------------------|

|                   |           |
|-------------------|-----------|
| <b>Self-Study</b> | 116 Hours |
|-------------------|-----------|

|                                  |                                                                                                                            |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Prerequisites</b> | Basics of electrical Engineering, especially alternating current calculations with complex numbers and three phase systems |
|----------------------------------|----------------------------------------------------------------------------------------------------------------------------|

**Mandatory Prerequisites**

|                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"><li>■ Klaus Heuck, Klaus-Dieter Dettmann, Detlef Schulz, "Elektrische Energieversorgung", 7. vollständig überarbeitete und erweiterte Auflage, Vieweg Verlag, Wiesbaden, 2007. ISBN 978-3-8348-0217-0</li><li>■ Dieter Nelles, Christian Tuttas, "Elektrische Energietechnik", B.G. Teubner Verlag, Stuttgart, 1998, ISBN 3-519-06427-8</li><li>■ Valentin Crastan, "Elektrische Energieversorgung 1: Netzelemente, Modellierung, stationäres Verhalten, Bemessung, Schalt- und Schutztechnik", 2. bearbeitete Auflage, Springer Verlag, Berlin Heidelberg New York, 2007, ISBN 978-3-540-69439-7</li><li>■ „Erzeugungsanlagen am Niederspannungsnetz – Technische Mindestanforderungen für Anschluss und Parallelbetrieb von Erzeugungsanlagen am Niederspannungsnetz“, VDE-Anwendungsregel VDE-AR-N 4105, Aug. 2011, verbindlich gültig ab 1.1.2012.</li></ul> |
| <b>Included in Elective Catalog</b>              | <ul style="list-style-type: none"><li>■ SV - Studienschwerpunktmodule</li><li>■ WM - Allgemeiner Wahlmodulbereich</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Included in Specialization</b>                | ET - Elektrische Energietechnik                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"><li>■ SNEE in Master Communication Systems and Networks PO3</li><li>■ SNEE in Master Communication Systems and Networks PO4</li><li>■ SNEE in Master Elektrotechnik PO3</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Last Update</b>                               | 19.7.2025, 14:32:16                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

### 6.33 SYE - Systemtechnik für Energieeffizienz

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                   |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| <b>Module ID</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | SYE                                                                                                                               |
| <b>Module Name</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Systemtechnik für Energieeffizienz                                                                                                |
| <b>Type of Module</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Elective Modules                                                                                                                  |
| <b>Recognized Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | SYE - Systems Engineering for Energy Efficiency                                                                                   |
| <b>ECTS credits</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 5                                                                                                                                 |
| <b>Language</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | deutsch, englisch bei Bedarf                                                                                                      |
| <b>Duration of Module</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 1 Semester                                                                                                                        |
| <b>Recommended Semester</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 1-2                                                                                                                               |
| <b>Frequency of Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | every winter term                                                                                                                 |
| <b>Module Coordinator</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Prof. Dr. Johanna May/Professor Fakultät IME                                                                                      |
| <b>Lecturer(s)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Prof. Dr. Johanna May/Professor Fakultät IME                                                                                      |
| <b>Learning Outcome(s)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                   |
| Bestehende und neuartige Systeme und Produkte systematisch auf energetische Optimierungspotenziale hin analysieren und daraus Verbesserungen für die Energieeffizienz ableiten, indem funktionelle Anforderungen in technische Kennzahlen übersetzt werden, messtechnische Verfahren angewandt und eigene sowie Werte aus der Literatur kritisch bewertet werden, starke Einflussparameter ermittelt werden, Kreativitätsmethoden angewendet werden, mit starken Einflüssen Funktionsmodelle simuliert werden und die Sichtweisen verschiedener Stakeholder berücksichtigt werden, um später im Beruf damit neuartige Systeme energieeffizienter konzipieren zu können oder bei bestehenden Systemen Anhaltspunkte zur Verbesserung der Energieeffizienz zu ermitteln. |                                                                                                                                   |
| <b>Module Contents</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                   |
| <b>Lecture / Exercises</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                   |
| electrical power measurements and thermography (lab), analyse load profiles and simulation in python, use relevant standards for evaluation of energy payback time, economic viability and life cycle analysis, overview over most frequenz energy efficiency measures (pressurized air, lighting, heat recovery)                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                   |
| translate functional requirements on systems and products into technical key parameters and document knowlegde, apply measurements and critically evaluate own and data from literature, find influencing factors, use creativity methods, simulate strong influence factors in functional models and evaluate potentials for improvement quantitatively, evaluate acceptance from different viewpoints                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                   |
| <b>Lab</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                   |
| thermography, measurement of electrical energy of more or less energy efficient consumers, measure electrical load profiles (at home), critical evaluation of measurement uncertainty                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                   |
| <b>Project</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                   |
| apply methods of lecture to a specific (every semester newly conceived) project topic in the area of energy efficiency, work in a team                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                   |
| <b>Teaching and Learning Methods</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <ul style="list-style-type: none"> <li>■ Lecture / Exercises</li> <li>■ Lab</li> <li>■ Project</li> </ul>                         |
| <b>Examination Types with Weights</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <ul style="list-style-type: none"> <li>■ accompanying: project work [50%] and</li> <li>■ final: oral examination [50%]</li> </ul> |
| <b>Workload</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 150 Hours                                                                                                                         |
| <b>Contact Hours</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 57 Hours $\pm$ 5 SWS                                                                                                              |
| <b>Self-Study</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 93 Hours                                                                                                                          |

|                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Prerequisites</b>                 | Bachelor electrical engineering, renewable energy or comparable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Mandatory Prerequisites</b>                   | <ul style="list-style-type: none"><li>▪ Project requires attendance in the amount of: 5 Projektermine, Präsentation, mündliche Prüfung</li><li>▪ Participation in final examination only after successful participation in Project</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Recommended Literature</b>                    | <ul style="list-style-type: none"><li>▪ M. Pehnt: Energieeffizienz: Ein Lehr- und Handbuch, Springer, 1. korrigierter Nachdruck 2010, ISBN 9783642142512</li><li>▪ M. Günther: Energieeffizienz durch Erneuerbare Energien: Möglichkeiten, Potenziale, Systeme, Springer Fachmedien Wiesbaden, 2015, ISBN 9783658067533</li><li>▪ F. Wosnitza, H.G. Hilgers: Energieeffizienz und Energiemanagement: Ein Überblick heutiger Möglichkeiten und Notwendigkeiten, Vieweg + Teubner Verlag, 2012, ISBN 9783834886712</li><li>▪ J. Hesselbach: Energie- und klimateffiziente Produktion: Grundlagen, Leitlinien und Praxisbeispiele, Vieweg + Teubner Verlag, 2012, ISBN 9781280786358</li><li>▪ Recherche über scopus, Webinare der EU (leonardo)</li></ul> |
| <b>Included in Elective Catalog</b>              | <ul style="list-style-type: none"><li>▪ SV - Studienschwerpunktmodule</li><li>▪ WM - Allgemeiner Wahlmodulbereich</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Included in Specialization</b>                | ET - Elektrische Energietechnik                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"><li>▪ SYE in Master Communication Systems and Networks PO3</li><li>▪ SYE in Master Communication Systems and Networks PO4</li><li>▪ SYE in Master Elektrotechnik PO3</li></ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Specifics and Notes</b>                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>Last Update</b>                               | 19.7.2025, 14:32:16                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

### 6.34 TED - Theoretische Elektrodynamik

|                             |                                                 |
|-----------------------------|-------------------------------------------------|
| <b>Module ID</b>            | TED                                             |
| <b>Module Name</b>          | Theoretische Elektrodynamik                     |
| <b>Type of Module</b>       | Mandatory Module                                |
| <b>Recognized Course</b>    | TED - Theoretical Electro Dynamics              |
| <b>ECTS credits</b>         | 5                                               |
| <b>Language</b>             | deutsch                                         |
| <b>Duration of Module</b>   | 1 Semester                                      |
| <b>Recommended Semester</b> | 2                                               |
| <b>Frequency of Course</b>  | every summer term                               |
| <b>Module Coordinator</b>   | Prof. Dr. Holger Weigand/Professor Fakultät IME |
| <b>Lecturer(s)</b>          | Prof. Dr. Holger Weigand/Professor Fakultät IME |

#### Learning Outcome(s)

Mikroskopische/differentielle Beschreibung der Elektrodynamik kennenlernen  
 Bedeutung/Interpretation der mikroskopisch, differentiellen Maxwell-und Material-Gleichungen kennenlernen  
 makroskopische aus differentielle Beschreibung ableiten  
 Potentialentwicklungen zur näherungsweisen Problemlösung anwenden  
 Analogien zwischen elektrisch und magnetischen Effekten zur Problemlösung kennenlernen  
  
 Lösungsansätze zu den Maxwell-Gleichungen kennenlernen und analysieren  
 elektrotechnischer Effekte aus Maxwellgleichungen ableiten  
 Potentialtheorien zur Lösung elektrotechnischer Fragestellungen anwenden  
 Vektoroperatoren und Integralsätze anwenden  
 3-dim Vektoranalysis und Integralsätze anwenden  
 Analogien zwischen elektrisch und magnetischen Effekten zur Problemlösung erkennen und nutzen  
 Kapazitäten und Induktivitäten beliebiger Ladungs- bzw. Stromverteilungen berechnen

**Module Contents****Lecture / Exercises**

Introduction into Electro Dynamics  
 Charges, currents  
 Forces, fields  
 Classical Electro Dynamics  
 Electrostatics  
 Field, potential  
 Polarization  
 Electrostatic energy  
 Capacity  
 Multi pole development  
 Interaction of charge distributions  
 Stationary electrical field  
 Magnetostatics  
 Stationary magnetical field  
 Vector potential  
 Magnetization  
 Magnetostatic energy  
 Inductivity  
 Quasi stationary electromagnetic fields  
 Induction effects  
 Skin effect  
 Rapidly changing electromagnetic fields  
 Electromagnetic waves  
 Reflection and diffraction  
 Knowledge of meaning of Maxwell- and material equations  
 Derivation of electric/magnetic potential/field from charge/current distributions  
 Development of potential / field to monopole, dipole, quadrupole and higher moments  
 Calculation of capacity/inductivity to charge/current distributions from energy balance  
 Derivation of Continuity equation, Kirchhoff Laws from Maxwell equations  
 Derivation and solving of diffusion/wave equations from Maxwell equations  
 Solving of macroscopic problems by integration of microscopic/differential description  
 Solving of training examples

**Teaching and Learning** Lecture / Exercises**Methods**

**Examination Types with Weights** ■ final: (digital) written exam or oral examination [100%]

**Workload** 150 Hours**Contact Hours** 34 Hours  $\pm$  3 SWS**Self-Study** 116 Hours

**Recommended Prerequisites** Vector analysis

**Mandatory Prerequisites**

**Recommended Literature** ■ Lehner: "Elektromagnetische feldtheorie für Ingenieure", Springer-Verlag  
 ■ Wunsch: "Elektromagnetische Felder", Verlag technik

**Included in Elective Catalog**

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**Included in  
Specialization**

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**Use of the Module in  
Other Study Programs**

- TED in Master Communication Systems and Networks PO3
- TED in Master Communication Systems and Networks PO4
- TED in Master Elektrotechnik PO3

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**Specifics and Notes**

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**Last Update**                      19.7.2025, 14:32:16



### 6.35 VAE - Virtual Acoustic Environments

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Module ID</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | VAE                                                                                                                                        |
| <b>Module Name</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Virtual Acoustic Environments                                                                                                              |
| <b>Type of Module</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Elective Modules                                                                                                                           |
| <b>Recognized Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | VAE - Virtual Acoustic Environments (VAE)                                                                                                  |
| <b>ECTS credits</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 5                                                                                                                                          |
| <b>Language</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | englisch                                                                                                                                   |
| <b>Duration of Module</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1 Semester                                                                                                                                 |
| <b>Recommended Semester</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 1-2                                                                                                                                        |
| <b>Frequency of Course</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | every summer term                                                                                                                          |
| <b>Module Coordinator</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Prof. Dr.-Ing. Christoph Pörschmann/Professor Fakultät IME                                                                                 |
| <b>Lecturer(s)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Prof. Dr.-Ing. Christoph Pörschmann/Professor Fakultät IME                                                                                 |
| <b>Learning Outcome(s)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                            |
| <p>What: The students learn the basic concepts , the technology and perception-related aspects of virtual acoustic environments. The course will be strongly related to research aspects and projects</p> <p>How: The students apply their knowledge on Signal Processing, Audio, and in the field of VR on different aspects of Virtual Acoustic Environments. Actual trends in research and state of the art applications will be integrated, tested, analyzed and evaluated.</p> <p>Aim: The students shall be able to work on research topics which consider topics which are scientifically new and relevant. Aspects of scalability and commercialization play a role</p> |                                                                                                                                            |
| <b>Module Contents</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                            |
| <b>Lecture</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                            |
| The basic concepts of headphone-based or loudspeaker-based VR-systems are introduced                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                            |
| <b>Project</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                            |
| In one specific topic of Virtual Acoustic Environments the students shall get deep know-how on the technology and apply it to a practical problem and present the results                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                            |
| <b>Lab</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                            |
| <b>Teaching and Learning Methods</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <ul style="list-style-type: none"> <li>▪ Lecture</li> <li>▪ Project</li> <li>▪ Lab</li> </ul>                                              |
| <b>Examination Types with Weights</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <ul style="list-style-type: none"> <li>▪ accompanying: project work [100%] and</li> <li>▪ accompanying: exercise lab [ungraded]</li> </ul> |
| <b>Workload</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 150 Hours                                                                                                                                  |
| <b>Contact Hours</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 45 Hours $\pm$ 4 SWS                                                                                                                       |
| <b>Self-Study</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 105 Hours                                                                                                                                  |
| <b>Recommended Prerequisites</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Know-how on Acoustics and audio signal processing                                                                                          |
| <b>Mandatory Prerequisites</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                            |

|                               |                                                                                                                                                                                                                                                                               |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recommended Literature</b> | <ul style="list-style-type: none"><li>▪ Rozinska, A. "Immersive Sound"</li><li>▪ Blauert, J. "Spatial Hearing"</li><li>▪ Zotter, F., Frank, M. "Ambisonics: A Practical 3D Audio Theory for Recording, Studio Production, Sound Reinforcement, and Virtual Reality"</li></ul> |
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|                                     |                                   |
|-------------------------------------|-----------------------------------|
| <b>Included in Elective Catalog</b> | WM - Allgemeiner Wahlmodulbereich |
|-------------------------------------|-----------------------------------|

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**Included in Specialization**

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| <b>Use of the Module in Other Study Programs</b> | <ul style="list-style-type: none"><li>▪ VAE in Master Communication Systems and Networks PO3</li><li>▪ VAE in Master Communication Systems and Networks PO4</li><li>▪ VAE in Master Medientechnologie PO3</li><li>▪ VAE in Master Medientechnologie PO4</li><li>▪ VAE in Master Technische Informatik PO3</li><li>▪ VAE in Master Informatik und Systems-Engineering PO1</li></ul> |
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**Specifics and Notes**

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| <b>Last Update</b> | 19.7.2025, 14:32:16 |
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### 6.36 ZR - Zustandsregelung

|                             |                                                |
|-----------------------------|------------------------------------------------|
| <b>Module ID</b>            | ZR                                             |
| <b>Module Name</b>          | Zustandsregelung                               |
| <b>Type of Module</b>       | Elective Modules                               |
| <b>Recognized Course</b>    | ZR - State Space Control                       |
| <b>ECTS credits</b>         | 5                                              |
| <b>Language</b>             | deutsch                                        |
| <b>Duration of Module</b>   | 1 Semester                                     |
| <b>Recommended Semester</b> | 1-2                                            |
| <b>Frequency of Course</b>  | every winter term                              |
| <b>Module Coordinator</b>   | Prof. Dr. Norbert Große/Professor Fakultät IME |
| <b>Lecturer(s)</b>          | Prof. Dr. Norbert Große/Professor Fakultät IME |

#### Learning Outcome(s)

- Digitale Regler (Einsatzgründe, Funktionsweise, Abtastzeiten)
- Differenzengleichungen
- z-Transformation
- Stabilität, Regelverhalten in Abhängigkeit der Pole
- Zustandsraum im Zeitkontinuierlichen
- Normalformen, Transformation der Zustandsraumdarstellung
- Steuerbarkeit, Beobachtbarkeit
- Reglerentwurf nach Polvorgabe
- Vorfilter, Kompensator
- Beobachterentwurf nach Polvorgabe
- Optimaler Reglerentwurf
- Zustandsraum im Zeitdiskreten

**Module Contents****Lecture / Exercises**

- | Sampling, quantization describe
- | describe time-discrete systems in the time domain
- | Describe time-discrete systems in the frequency domain
- | Analyze the stability and position of the poles of the transfer function
- | state space description of a system
- | Describe time-continuously
- | Describe time-discretely
- | Transform to normal forms
- | Determine stability, controllability, observability
- | Design state space controller according to pole assignment
- | Design optimal state space controller
- | Prefilter and noise compensation design
- | Design of observers with pole placement
- | Design of optimal observers
- | Create models from a physical perspective
- | Select suitable state variables
- | Perform simulation of dynamic systems

**Project**

- | Use spreadsheet programs for difference equations
- | Use matrix calculation programs
- | Perform simulation of dynamic systems
- | Review design of complex dynamic systems

**Teaching and Learning Methods**

- Lecture / Exercises
- Project

**Examination Types with Weights**

- accompanying: project work [ungraded] and
- final: (digital) written exam or oral examination [100%]

**Workload** 150 Hours

**Contact Hours** 45 Hours  $\pm$  4 SWS

**Self-Study** 105 Hours

**Recommended Prerequisites** Basics of control engineering  
differential equations, Laplace transformation, frequency domain;  
Matrix calculation

**Mandatory Prerequisites**

**Recommended Literature**

- Taschenbuch der praktischen Regelungstechnik, Große, Schorn, Hanser Verlag

**Included in Elective Catalog**

- SV - Studienschwerpunktmodule
- WM - Allgemeiner Wahlmodulbereich

**Included in Specialization** AU - Automatisierungstechnik

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|                                                      |                                 |
|------------------------------------------------------|---------------------------------|
| <b>Use of the Module in<br/>Other Study Programs</b> | ZR in Master Elektrotechnik PO3 |
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**Specifics and Notes**

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## 7. Electives Catalogs

The following shows which modules can be selected in a particular elective area. The following notes and regulations apply to all elective areas:

- **When choosing modules from elective catalogs, the conditions formulated in Specializations also apply.**
- The semester in which elective modules of an elective catalog can typically be taken can be found in the study plans.
- As a rule, modules are only offered in either the summer or winter semester. This means that any required accompanying examination can only be taken in this semester. The summative examinations for modules in Faculty 07 are usually offered in the examination period after each semester.
- A completed module is recognized for a maximum of one elective area, even if it is listed in several elective areas.
- There is an admission restriction for some modules. More information on this can be found in the announcements on admission restrictions.
- Registration and admission to non-faculty modules are subject to deadlines and other conditions set by the faculty or university offering the module. Their admission cannot be guaranteed. Students must contact the relevant external lecturer in good time to find out whether they are allowed to take part in an external module and what they need to do to register and participate.
- Upon application, a suitable modules can be added to the elective area. Such an application must be submitted informally to the head of degree program at least four months before the planned participation in that module. The examination board decides on the acceptance of the application in consultation with the head of degree program and suitable teaching staff. A study achievement to be recognized
  - must fit in with the intended graduate profile of the degree program and contribute to its achievement,
  - must be oriented towards learning outcomes and must not serve solely to impart knowledge,
  - must correspond to the qualification level of a Master's degree program,
  - must represent a meaningful increase in competence against the background of the intended course of study,
  - must have been completed by an examination and
  - must not be identical in terms of content and learning outcomes to coursework that has already been completed.
- Modules are not listed below,
  - which in the past were only recognized for an elective catalog as part of individual recognition procedures or
  - which in the past were only recognized for an elective catalog as part of a stay abroad and the associated individual learning agreement.

### Stays abroad

- Students who have integrated a stay abroad into their studies and have completed coursework at a foreign university can have this recognized upon application and with the approval of the examination board.
- A Learning Agreement must be concluded with the Faculty's Recognition Officer before the start of the stay abroad. In particular, it is agreed for which mandatory modules or elective catalogs the coursework completed abroad will be recognized.

### 7.1 BTH - Beliebiges Modul aus einem Masterstudiengang der TH Köln

Beliebiges Modul aus einem Masterstudiengang der TH Köln

You must select modules of 5 ECTS credit points in total out of this catalog.

## 7.2 SV - Studienschwerpunktmodule

You must select modules of 15 ECTS credit points in total out of this catalog.

This elective catalog particularly includes all modules from the following areas:

- Specialization AU - Automatisierungstechnik
- Specialization ET - Elektrische Energietechnik
- Specialization OT - Optische Technologien

Modules from these other areas are printed normally in the following, original modules from this elective area are printed in bold.

Modules of the faculty:

| Module ID | Module Name                                            | ECTS | included in Specialization |    |
|-----------|--------------------------------------------------------|------|----------------------------|----|
| CSO       | Computersimulation in der Optik                        | 5    |                            | OT |
| DMC       | Digital Motion Control                                 | 5    | AU                         |    |
| EMM       | Energiemanagement in Energieverbundsystemen            | 5    |                            | ET |
| HSUT      | Hochspannungsübertragungstechnik                       | 5    |                            | ET |
| NLO       | Nichtlineare Optik                                     | 5    |                            | OT |
| QEKs      | Qualitätsgesteuerter Entwurf komplexer Softwaresysteme | 5    | AU                         |    |
| QM        | Quantenmechanik                                        | 5    |                            | OT |
| SNEE      | Stromnetze für erneuerbare Energien                    | 5    |                            | ET |
| SYE       | Systemtechnik für Energieeffizienz                     | 5    |                            | ET |
| ZR        | Zustandsregelung                                       | 5    | AU                         |    |

### 7.3 WM - Allgemeiner Wahlmodulbereich

You must select modules of 10 ECTS credit points in total out of this catalog.

This elective catalog particularly includes all modules from the following areas:

- Electives Catalog SV - Studienschwerpunktmodule

Modules from these other areas are printed normally in the following, original modules from this elective area are printed in bold.

Modules of the faculty:

| Module ID   | Module Name                                                             | ECTS | included in Specialization |
|-------------|-------------------------------------------------------------------------|------|----------------------------|
| <b>ACC</b>  | <b>Advanced Channel Coding</b>                                          | 5    |                            |
| <b>BSN</b>  | <b>Fundamentals of System and Network Theory</b>                        | 5    |                            |
| CSO         | Computersimulation in der Optik                                         | 5    | OT                         |
| <b>DLO</b>  | <b>Deep Learning und Objekterkennung</b>                                | 5    |                            |
| DMC         | Digital Motion Control                                                  | 5    | AU                         |
| <b>DSP</b>  | <b>Digital Signal Processing</b>                                        | 5    |                            |
| <b>EBA</b>  | <b>Elektrische Bahnen</b>                                               | 5    |                            |
| <b>EFA</b>  | <b>Elektrische Fahrzeugantriebe</b>                                     | 5    |                            |
| EMM         | Energiemanagement in Energieverbundsystemen                             | 5    | ET                         |
| <b>ERMK</b> | <b>Entrepreneurship, Gewerblicher Rechtsschutz, Market Knowledge</b>    | 5    |                            |
| <b>ESD</b>  | <b>Embedded Systems Design</b>                                          | 5    |                            |
| HSUT        | Hochspannungsübertragungstechnik                                        | 5    | ET                         |
| <b>IBD</b>  | <b>InnoBioDiv</b>                                                       | 5    |                            |
| <b>ITF</b>  | <b>IT-Forensik</b>                                                      | 5    |                            |
| <b>LCSS</b> | <b>Large and Cloud-based Software-Systems</b>                           | 5    |                            |
| <b>LSPW</b> | <b>Leistungselektronische Stellglieder für PV- und Windkraftanlagen</b> | 5    |                            |
| <b>MLWR</b> | <b>Maschinelles Lernen und wissenschaftliches Rechnen</b>               | 5    |                            |
| <b>NGN</b>  | <b>Next Generation Networks</b>                                         | 5    |                            |
| NLO         | Nichtlineare Optik                                                      | 5    | OT                         |
| <b>OSA</b>  | <b>Optische Spektroskopie und Anwendungen</b>                           | 5    |                            |
| QEKs        | Qualitätsgesteuerter Entwurf komplexer Softwaresysteme                  | 5    | AU                         |
| QM          | Quantenmechanik                                                         | 5    | OT                         |
| <b>RFSD</b> | <b>RF System Design</b>                                                 | 5    |                            |
| <b>RM</b>   | <b>Rastermikroskopie</b>                                                | 5    |                            |
| SNEE        | Stromnetze für erneuerbare Energien                                     | 5    | ET                         |



| Module |                                    |      |                            |
|--------|------------------------------------|------|----------------------------|
| ID     | Module Name                        | ECTS | included in Specialization |
| SYE    | Systemtechnik für Energieeffizienz | 5    | ET                         |
| VAE    | Virtual Acoustic Environments      | 5    |                            |
| ZR     | Zustandsregelung                   | 5    | AU                         |

## 8. Specializations

The following section outlines the major fields of study defined in this degree program (see also §24 of the examination regulations). The following information and regulations apply to all major fields of study:

- A major field of study is considered successfully completed if the modules listed therein, comprising at least 15 ECTS, have been successfully completed.
- **At least one major field of study must be completed.**
- The completed areas of specialization are listed in a separate appendix to the degree certificate; if there is more than one, only parts of it may be listed upon request to the Examination Office.
- Upon request, a major field of study can be supplemented with additional suitable modules. Such a request must be submitted informally to the program director at least six months before planned participation in a module to be supplemented. The examination board decides on the acceptance of the request in consultation with the program director and appropriately qualified teaching staff.

### 8.1 AU - Automatisierungstechnik

Modules of the faculty:

| Abbr. | Module Name                                            | ECTS |
|-------|--------------------------------------------------------|------|
| DMC   | Digital Motion Control                                 | 5    |
| QEKS  | Qualitätsgesteuerter Entwurf komplexer Softwaresysteme | 5    |
| ZR    | Zustandsregelung                                       | 5    |

## 8.2 ET - Elektrische Energietechnik

Modules of the faculty:

| Abbr. | Module Name                                 | ECTS |
|-------|---------------------------------------------|------|
| EMM   | Energiemanagement in Energieverbundsystemen | 5    |
| HSUT  | Hochspannungsübertragungstechnik            | 5    |
| SNEE  | Stromnetze für erneuerbare Energien         | 5    |
| SYE   | Systemtechnik für Energieeffizienz          | 5    |

### 8.3 OT - Optische Technologien

Modules of the faculty:

| Abbr. | Module Name                     | ECTS |
|-------|---------------------------------|------|
| CSO   | Computersimulation in der Optik | 5    |
| NLO   | Nichtlineare Optik              | 5    |
| QM    | Quantenmechanik                 | 5    |

## 9. Examination Types

The forms of examination referenced in the module descriptions are explained in more detail below. The explanations are taken from the examination regulations, §19ff. In case of deviations, the text of the examination regulations applies.

### **(Digital) Written exam**

Written, paper-based or digitally supported examination. Details are regulated in §19 of the examination regulations.

### **Oral examination**

Examination to be taken orally. Details are regulated in §21 of the examination regulations.

### **Oral contribution**

See §22, para. 5 of the examination regulations: An oral contribution (e.g. paper, presentation, negotiation, moderation) serves to determine whether students are capable of independently working on a practice-oriented task within a specified period of time using scientific and practical methods and presenting it in a technically appropriate manner by means of verbal communication. This also includes answering questions from the auditorium regarding the oral presentation. The duration of the oral presentation is determined by the examiner at the beginning of the semester. The facts relevant to the grading of the oral presentation are to be recorded in a protocol; students should also submit the written documents relating to the oral presentation for documentation purposes. Students must be notified of the grade no later than one week after the oral presentation.

### **Technical discussion**

See §22, Para. 8 of the examination regulations: A technical discussion serves to determine professional competence, understanding of complex technical contexts and the ability to solve problems analytically. Students and examiners have roughly equal speaking time in the technical discussion in order to enable a discursive technical exchange. One or more discussions are held with an examiner during the semester or in summary form. Students should present and explain practice-related technical tasks, problems or project plans from the degree program and explain the relevant technical background, theoretical concepts and methodological approaches for processing the tasks. Possible solutions, procedures and considerations for solving the problem must be discussed and justified. The facts relevant to the grading of the technical discussion must be recorded in a protocol.

### **Project work**

See §22, Para. 6 of the examination regulations: The project work is an examination that consists of independently working on a specific problem under supervision using scientific methodology and documenting the results. In addition to the quality of the answer to the question, the organizational and communicative quality of the implementation, such as slides, presentations, milestones, project plans, meeting minutes, etc., are also relevant for assessment.

### **Lab report**

See §22, para. 10 of the examination regulations: An internship report (e.g. experimental protocol) serves to determine whether students are capable of independently carrying out a practical laboratory task within a specified period of time, as well as documenting, evaluating and reflecting on the process and results in writing. Preparatory homework may be required before the actual experiment is carried out. Technical discussions may take place during or after the experiment. Internship reports can also be admitted to the examination in the form of group work. Students must be notified of the assessment of the practical placement report no later than six weeks after submission of the report.

### **Exercise lab**

See §22, para. 11 of the examination regulations: The examination form "practical training" tests the technical skills in the application of the theories and concepts learned in the lecture as well as practical skills, for example the use of development tools and technologies. For this purpose, several tasks are set during the semester, which are to be solved either alone or in group work, on site or as homework by a given deadline. The solutions to the tasks must be submitted by the students in (digital) written form. The exact criteria for passing the examination will be announced at the beginning of the corresponding course.

### **Exercise lab under examination conditions**

See §22, para. 11, sentence 5 of the examination regulations: A "practical training course under examination conditions" is a practical training course in which the tasks are to be completed within the time frame and under the independent conditions of an examination.

### **Term paper**

See §22, para. 3 of the examination regulations: A term paper (e.g. case study, research) serves to determine whether students are capable of independently completing a specialist task in written or electronic form using scientific and practical methods within a specified period of time. The topic and scope (e.g. number of pages of the text section) of the term paper are determined by the examiner at the beginning of the semester. A declaration of independence must be signed and submitted by the candidate. In addition, technical discussions may be held.

### **Learning portfolio**

A learning portfolio documents the student competence development process by means of presentations, essays, excerpts from internship reports, tables of contents of term papers, notes, to-do lists, research reports and other performance presentations and learning productions, summarized as so-called "artefacts". The learning portfolio only becomes an examination item in conjunction with the student's reflection (in writing, orally or in a video) on the use of these artifacts to achieve the learning objective previously made transparent by the examiner. During the creation of the learning portfolio, feedback on development steps and/or artifacts is given over the course of the semester. A revised form of the learning portfolio - in handwritten or electronic form - is submitted as the examination result following the feedback.

### **Single / Multiple choice**

See §20 of the examination regulations.

### **Access colloquium**

See §22, para. 12 of the examination regulations: An entrance colloquium serves to determine whether the students fulfill the specific requirements to be able to work independently and safely on a defined practical laboratory task using scientific and practical methods.

### **(Intermediate) Certificate**

See §22, para. 7 of the examination regulations: A test/intermediate test certifies that the student has completed a piece of coursework (e.g. draft) to the required standard. The scope of work to be completed and the required content and requirements can be found in the respective module description in the module handbook and in the assignment.

### **Open book preparation**

The open book assignment (OBA) is a short term paper and therefore an unsupervised written or electronic examination. It is characterized by the fact that, according to the examiner's declaration of aids, all aids are generally permitted. Special attention is drawn to the safeguarding of good scientific practice through proper citation etc. and the requirement of independence in the performance of each examination.

### **Thesis**

Bachelor's or Master's thesis as defined in the examination regulations §25ff: The Master's thesis is a written assignment. It should show that the student is capable of independently working on a topic from their subject area within a specified period of time, both in its technical details and in its interdisciplinary contexts, using scientific and practical methods. Interdisciplinary cooperation can also be taken into account in the final thesis.

### **Colloquium**

Colloquium for the Bachelor's or Master's thesis as defined in the examination regulations §29: The colloquium serves to determine whether the student is able to present the results of the Master's thesis, its technical and methodological foundations, interdisciplinary contexts and extracurricular references orally, to justify them independently and to assess their significance for practice.

## 10. Profile Module Matrix

The following section describes the extent to which the modules of the degree program support and develop the competencies and fields of action of the study program as well as certain study program criteria as defined by the University of Applied Science TH Köln.

| Abbr. | Module Name                                                   | HF1 - Entwicklung und Design | HF2 - Forschung und Innovation | HF3 - Leitung und Management | HF4 - Qualitätssicherung und Te... | K.1 - Entwicklung und Konzeptio... | K.2 - Prüfung und Bewertung kom... | K.3 - Wissenschaftliches Arbeit... | K.4 - Projektmanagement und Tea... | K.5 - Selbstorganisation und au... | K.6 - Kommunikation und Interku... | K.7 - Technische und naturwisse... | K.8 - Nachhaltigkeit und gesell... | K.9 - Analyse, Simulation und A... | K.10 - Führungs- und Entscheidun... | K.11 - Anwendung ethischer Werte... | K.12 - Integratives Denken und H... | K.13 - Innovation und Kreativität... | SK.1 - Global Citizenship | SK.2 - Internationalisierung | SK.3 - Interdisziplinarität | SK.4 - Transfer |
|-------|---------------------------------------------------------------|------------------------------|--------------------------------|------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|--------------------------------------|---------------------------|------------------------------|-----------------------------|-----------------|
| ACC   | Advanced Channel Coding                                       | ●                            | ●                              |                              | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  |                                    |                                    |                                    | ●                                  | ●                                   |                                     | ●                                   | ●                                    | ●                         | ●                            |                             |                 |
| BSN   | Basics on Systems and Networks                                |                              | ●                              |                              | ●                                  |                                    | ●                                  |                                    |                                    | ●                                  |                                    | ●                                  |                                    | ●                                  |                                     |                                     |                                     |                                      |                           | ●                            | ●                           |                 |
| CSO   | Computersimulation in der Optik                               | ●                            | ●                              | ●                            | ●                                  | ●                                  | ●                                  | ●                                  |                                    | ●                                  | ●                                  | ●                                  |                                    | ●                                  | ●                                   |                                     |                                     | ●                                    |                           |                              |                             |                 |
| DLO   | Deep Learning und Objekterkennung                             | ●                            | ●                              |                              | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  |                                    | ●                                  |                                    |                                    | ●                                  |                                     | ●                                   |                                     |                                      |                           |                              |                             |                 |
| DMC   | Digital Motion Control                                        | ●                            | ●                              |                              | ●                                  | ●                                  | ●                                  |                                    |                                    | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  |                                     | ●                                   | ●                                   |                                      |                           |                              |                             |                 |
| DSP   | Digital Signal Processing                                     | ●                            | ●                              |                              | ●                                  | ●                                  | ●                                  | ●                                  |                                    | ●                                  |                                    |                                    |                                    | ●                                  |                                     |                                     | ●                                   |                                      |                           |                              | ●                           |                 |
| EBA   | Elektrische Bahnen                                            | ●                            | ●                              |                              | ●                                  | ●                                  | ●                                  | ●                                  |                                    | ●                                  | ●                                  |                                    | ●                                  | ●                                  |                                     |                                     |                                     | ●                                    |                           |                              |                             |                 |
| EFA   | Elektrische Fahrzeugantriebe                                  | ●                            | ●                              | ●                            | ●                                  | ●                                  | ●                                  | ●                                  |                                    | ●                                  |                                    |                                    | ●                                  | ●                                  |                                     |                                     |                                     | ●                                    |                           |                              |                             |                 |
| EMM   | Energiemanagement in Energieverbundsystemen                   |                              | ●                              | ●                            |                                    |                                    | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                   |                                     | ●                                   |                                      |                           |                              |                             |                 |
| ERMK  | Entrepreneurship, Gewerblicher Rechtsschutz, Market Knowledge |                              |                                |                              |                                    |                                    |                                    |                                    |                                    |                                    |                                    |                                    |                                    |                                    |                                     |                                     |                                     |                                      |                           |                              |                             |                 |
| ESD   | Embedded Systems Design                                       | ●                            |                                |                              |                                    | ●                                  | ●                                  |                                    | ●                                  | ●                                  | ●                                  | ●                                  |                                    | ●                                  |                                     |                                     |                                     | ●                                    |                           | ●                            | ●                           | ●               |
| FS    | Forschungsseminar                                             | ●                            | ●                              | ●                            | ●                                  |                                    | ●                                  | ●                                  |                                    | ●                                  | ●                                  |                                    | ●                                  | ●                                  | ●                                   |                                     |                                     |                                      |                           |                              |                             |                 |
| HIM   | Advanced Mathematics                                          |                              |                                |                              | ●                                  |                                    | ●                                  | ●                                  |                                    |                                    |                                    |                                    |                                    | ●                                  |                                     |                                     |                                     |                                      |                           | ●                            |                             |                 |
| HSUT  | Hochspannungsübertragungstechnik                              | ●                            | ●                              |                              | ●                                  | ●                                  | ●                                  | ●                                  |                                    | ●                                  | ●                                  |                                    | ●                                  | ●                                  |                                     |                                     |                                     | ●                                    |                           |                              |                             |                 |
| IBD   | InnoBioDiv                                                    |                              |                                |                              |                                    | ●                                  | ●                                  | ●                                  |                                    | ●                                  | ●                                  | ●                                  |                                    |                                    |                                     |                                     |                                     | ●                                    | ●                         | ●                            | ●                           | ●               |
| ITF   | IT-Forensik                                                   | ●                            |                                |                              | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  |                                    |                                    |                                    | ●                                  | ●                                   |                                     | ●                                   | ●                                    |                           |                              |                             |                 |

| Abbr. | Module Name                                                      | HF1 - Entwicklung und Design | HF2 - Forschung und Innovation | HF3 - Leitung und Management | HF4 - Qualitätssicherung und Te... | K.1 - Entwicklung und Konzeptio... | K.2 - Prüfung und Bewertung kom... | K.3 - Wissenschaftliches Arbeit... | K.4 - Projektmanagement und Tea... | K.5 - Selbstorganisation und au... | K.6 - Kommunikation und interku... | K.7 - Technische und naturwisse... | K.8 - Nachhaltigkeit und gesell... | K.9 - Analyse, Simulation und A... | K.10 - Führungs- und Entscheidun... | K.11 - Anwendung ethischer Werte... | K.12 - Integratives Denken und H... | K.13 - Innovation und Kreativität... | SK.1 - Global Citizenship | SK.2 - Internationalisierung | SK.3 - Interdisziplinarität | SK.4 - Transfer |
|-------|------------------------------------------------------------------|------------------------------|--------------------------------|------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|--------------------------------------|---------------------------|------------------------------|-----------------------------|-----------------|
| KOLL  | Kolloquium zur Masterarbeit                                      | ●                            | ●                              | ●                            | ●                                  |                                    |                                    |                                    |                                    | ●                                  | ●                                  |                                    |                                    |                                    |                                     |                                     |                                     |                                      |                           |                              |                             |                 |
| LCSS  | Large and Cloud-based Software-Systems                           | ●                            | ●                              | ●                            | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  |                                    | ●                                  |                                     |                                     | ●                                   | ●                                    |                           | ●                            |                             | ●               |
| LSPW  | Leistungselektronische Stellglieder für PV- und Windkraftanlagen | ●                            | ●                              | ●                            | ●                                  | ●                                  | ●                                  | ●                                  |                                    | ●                                  |                                    |                                    | ●                                  | ●                                  |                                     |                                     |                                     | ●                                    |                           |                              |                             |                 |
| MAA   | Masterarbeit                                                     | ●                            | ●                              | ●                            | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                   | ●                                   | ●                                   | ●                                    |                           |                              | ●                           | ●               |
| MLWR  | Maschinelles Lernen und wissenschaftliches Rechnen               |                              |                                |                              |                                    |                                    |                                    | ●                                  |                                    | ●                                  |                                    |                                    | ●                                  | ●                                  |                                     | ●                                   | ●                                   | ●                                    |                           |                              | ●                           | ●               |
| NGN   | Next Generation Networks                                         | ●                            | ●                              |                              | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  |                                    |                                    | ●                                  |                                     |                                     |                                     | ●                                    |                           | ●                            |                             |                 |
| NLO   | Nichtlineare Optik                                               | ●                            | ●                              | ●                            | ●                                  |                                    | ●                                  | ●                                  |                                    | ●                                  | ●                                  | ●                                  |                                    | ●                                  |                                     |                                     |                                     |                                      |                           |                              |                             |                 |
| OSA   | Optische Spektroskopie und Anwendungen                           | ●                            | ●                              | ●                            | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  |                                    | ●                                  | ●                                   |                                     | ●                                   | ●                                    |                           |                              |                             |                 |
| PLET  | Projektleitung                                                   | ●                            | ●                              | ●                            | ●                                  |                                    |                                    | ●                                  | ●                                  |                                    | ●                                  |                                    | ●                                  |                                    | ●                                   | ●                                   | ●                                   |                                      | ●                         |                              | ●                           |                 |
| QEKs  | Qualitätsgesteuerter Entwurf komplexer Softwaresysteme           | ●                            | ●                              | ●                            | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                   | ●                                   | ●                                   | ●                                    |                           |                              |                             |                 |
| QM    | Quantenmechanik                                                  |                              | ●                              |                              | ●                                  | ●                                  | ●                                  |                                    |                                    | ●                                  | ●                                  | ●                                  |                                    | ●                                  |                                     |                                     |                                     | ●                                    |                           |                              |                             |                 |
| RA    | Reflexion<br>Auslandssemester                                    |                              |                                |                              |                                    |                                    |                                    |                                    |                                    |                                    |                                    |                                    |                                    |                                    |                                     |                                     |                                     | ●                                    | ●                         | ●                            |                             |                 |
| RFSD  | RF System Design                                                 |                              | ●                              |                              | ●                                  | ●                                  | ●                                  | ●                                  |                                    |                                    | ●                                  |                                    |                                    | ●                                  |                                     |                                     |                                     | ●                                    |                           | ●                            | ●                           |                 |
| RM    | Rastermikroskopie                                                | ●                            | ●                              |                              | ●                                  |                                    | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  |                                    | ●                                  |                                     |                                     | ●                                   |                                      |                           |                              |                             |                 |
| SIM   | Simulation in der Ingenieurwissenschaft                          | ●                            | ●                              | ●                            | ●                                  | ●                                  |                                    | ●                                  | ●                                  | ●                                  |                                    |                                    |                                    | ●                                  | ●                                   |                                     | ●                                   | ●                                    |                           |                              |                             |                 |
| SNEE  | Stromnetze für erneuerbare Energien                              | ●                            | ●                              | ●                            | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  | ●                                   |                                     | ●                                   | ●                                    |                           |                              |                             |                 |
| SYE   | Systemtechnik für Energieeffizienz                               | ●                            | ●                              | ●                            | ●                                  |                                    | ●                                  | ●                                  | ●                                  |                                    | ●                                  |                                    | ●                                  | ●                                  | ●                                   |                                     | ●                                   |                                      |                           |                              |                             |                 |



| Abbr. | Module Name                   | HF1 - Entwicklung und Design | HF2 - Forschung und Innovation | HF3 - Leitung und Management | HF4 - Qualitätssicherung und Te... | K.1 - Entwicklung und Konzeptio... | K.2 - Prüfung und Bewertung kom... | K.3 - Wissenschaftliches Arbeit... | K.4 - Projektmanagement und Tea... | K.5 - Selbstorganisation und au... | K.6 - Kommunikation und interku... | K.7 - Technische und naturwisse... | K.8 - Nachhaltigkeit und gesell... | K.9 - Analyse, Simulation und A... | K.10 - Führungs- und Entscheidun... | K.11 - Anwendung ethischer Werte... | K.12 - Integratives Denken und H... | K.13 - Innovation und Kreativität... | SK.1 - Global Citizenship | SK.2 - Internationalisierung | SK.3 - Interdisziplinarität | SK.4 - Transfer |
|-------|-------------------------------|------------------------------|--------------------------------|------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|--------------------------------------|---------------------------|------------------------------|-----------------------------|-----------------|
| TED   | Theoretische Elektrodynamik   |                              | ●                              |                              |                                    |                                    |                                    | ●                                  |                                    |                                    | ●                                  | ●                                  |                                    | ●                                  |                                     |                                     |                                     |                                      |                           |                              |                             |                 |
| VAE   | Virtual Acoustic Environments | ●                            | ●                              |                              | ●                                  | ●                                  | ●                                  | ●                                  | ●                                  |                                    |                                    |                                    |                                    |                                    | ●                                   |                                     | ●                                   |                                      |                           |                              | ●                           | ●               |
| ZR    | Zustandsregelung              | ●                            | ●                              |                              | ●                                  | ●                                  | ●                                  | ●                                  |                                    | ●                                  |                                    | ●                                  |                                    | ●                                  |                                     |                                     |                                     | ●                                    |                           |                              |                             |                 |

## 11. Version History

The table below lists the different versions of the course offer. The versions are sorted in reverse chronological order with the currently valid version in the first row. The individual versions can be accessed via the link in the right-hand column on the right.

| Version | Date                | Changes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Link                 |
|---------|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|
| 1.3     | 2025-09-18-14-14-00 | 1. Publierte Prüfungsordnungs-Anhänge der reakkreditierten Studiengänge                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <a href="#">Link</a> |
| 1.2     | 2025-09-08-09-32-00 | 1. Diverse hängende Referenzen von Wahlbereichs-, Schwerpunkts- bzw. Vertiefungspaket-Tabellen in den Modul-Abschnitt korrigiert. Fehlende Module sind jetzt vorhanden.<br>2. Eine Modulbeschreibung beinhaltet nun auch Angaben, in welchen Wahlbereichen und Studienschwerpunkten bzw. Vertiefungspakten das jeweilige Modul enthalten ist.<br>3. Prüfungsvorleistungen in BSN reduziert<br>4. CSO mit Prüfungsform für begleitende Prüfung<br>5. Prüfungsordnungsversionen statt Jahreszahlen<br>6. Modulkürzel ohne Studiengang | <a href="#">Link</a> |
| 1.1     | 2025-06-24-18-55-09 | 1. Reakkreditierte Version                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <a href="#">Link</a> |
| 1.0     | 2024-12-06-08-45-55 | 1. Begutachtete Version für Reakkreditierung 2024<br>2. Neues Layout für sämtliche Modulhandbücher                                                                                                                                                                                                                                                                                                                                                                                                                                  | <a href="#">Link</a> |

Impressum

Datenschutzhinweis

Haftungshinweis

Bei Fehlern, bitte Mitteilung an  
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