OTH REGENSBURG

Module Handbook

for the Master's programme

Electrical and Microsystems Engineering (M.Eng.)

SPO version from: Summer semester 2025

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2025 by Laura Petersen

Faculty of Applied Natural and Cultural Sciences

Notes

1. The information on the workload in the form of ECTS credits in a module in this degree programme is based on the following:

1 ECTS credit corresponds to an average workload of 30 hours, comprising classroom attendance and self-study (45 minutes of teaching are counted as 1 hour).

2. Explanations on the structure of the module handbook

The degree programme is divided into three main areas:

- **Basic** module block
- **Advanced** module block
- **Interdisciplinary** module block

as well as the project and Master's thesis. The modules are sorted alphabetically. One or more courses are assigned to each module. The description of the assigned courses follows each module. By clicking on the module or the courses in the table of contents, you will be taken directly to the respective module description.

2.1 Basic modules

Depending on your previous bachelor's degree programme, you may not be able to enrol in all of the basic modules offered. Information on enrolment can be found in the module descriptions of the basic blocks under "Compulsory enrolment and options".

3. Standard aids:

The approved aids for written examinations can be found in the current semester's study plan table.

The following aids are permitted in all examinations:

- Blank writing paper (your name, student ID number and module name may be written on the paper in advance)
- All types of writing implements (except red pens)
- Compasses, rulers of all kinds, erasers, pencil sharpeners, ink removers
- Approved calculators from the Faculties of Applied Natural and Cultural Sciences and Electrical Engineering and Information Technology
- Exceptions to this rule are explicitly stated in the "Permitted aids" column in the study plan table.

For examinations marked "none", only standard aids are permitted.

Please also note that the use of any communication devices (telephones, watches, glasses, etc.) is prohibited.

4. Language of instruction:

The languages of instruction in the programme are German and English. Information on the language of instruction in the module can be found in the respective module descriptions.

5. Other

The general rules of the SPO and APO apply.

In addition to the module handbook, please always refer to the current semester's study plan table for the programme!

Module list

Focus: BASIS

Focus: INTERDISCIPLINARY

Focus: CONSOLIDATION

Usability of modules: All modules are specific to the degree programme. Deviations are noted in the module descriptions in the "Study and examination performance" field.

Module name (English name, if applicable)	Module code or no.
INTERDISCIPLINARY	

Module coordinator	Faculty
N.N.	Organisational units

Semester according to the study plan	Study section	Module type	Workload [ECTS credits]
		Focus (Structural element)	

Assigned sub-modules:

No	Name of submodules	Scope of teaching [SWS or UE]	Workload [ECTS credits]

Module designation (English designation if applicable)	Module code or number
Master's thesis	MA/M1

Module coordinator	Faculty
Prof. Dr Johannes Wild	Applied Natural and Cultural Sciences

Semester according to study plan	Stage of study	Module type	Workload [ECTS credits]
3		Compulsory	26

Mandatory prerequisites
The topic can only be chosen if at least 40 credits have been achieved in the course of study.

Contents
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Learning objectives: Personal competence
After successfully completing the module, students will be able to See following pages

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Assigned sub-modules:

No	Name of sub-modules	Teaching scope [SWS or UE]	Workload [ECTS credits]
1.	Thesis defence (Disputation)		6
2.	Written paper (Written paper)		20

Information on compulsory enrolment or options
For processing times and further provisions, see also SPO and APO **Requirements for dual students:** In addition to the Master's thesis, at least 3 months of This should be completed at the latest before the start of the Master's thesis with the practice partner (e.g. during the semester break). This industrial practice should be directly related to the topics of the project and Master's thesis and serves as preparation and familiarisation with the topic of the Master's thesis. For dual students , the industrial placement, project work and Master's thesis form a single unit that covers a period

of at least 9 months with the industry partner and is a special feature of the dual study model.

Submodule	**TM abbreviation**
Disputation (Disputation)	

Responsible	Faculty
Prof. Dr Johannes Wild	Applied Natural and Cultural Sciences
Lecturer	Frequency
Supervising professor	Every semester

Teaching format
Independent presentation of a scientific project (optional in English).

Semesters of study according to the curriculum	Teaching load [SWS or UE]	Language of instruction	Workload [ECTS credits]
3		German/English	6

Time commitment:

Classroom study	Independent study
	180

Coursework and examination
Presentation, 30 min.
Permitted aids for performance assessment
See study plan table

Contents
Oral presentation and justification of the results obtained. In this context, appropriate presentation techniques must be learned.
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to orally present and independently justify the results of a comprehensive scientific or engineering project, its technical fundamentals and interdisciplinary connections (3).
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to • analyse their own learning progress and learning needs (3) and, if necessary, derive courses of action from this (3), • work together with others in a goal-oriented manner (2), understand their interests and social situation (2), deal with them rationally and responsibly and communicate with them (2), and help shape the world of work and life (3), • work scientifically in accordance with the "rules of good scientific practice" (2), present specialist content (2) and present it to an audience using correct technical language (2).

Literature
The available state of the art.

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Written paper	

Responsible	Faculty
Prof. Dr Johannes Wild	Applied Natural and Cultural Sciences
Lecturer	Frequency
Supervising professor	Every semester

Teaching format
Independent engineering work using scientific methods with documentation and under the expert guidance of the respective supervising lecturers (optionally in English).

Semester according to the study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
3		German/English	20

Time commitment:

Classroom study	Independent study
	750

Study and examination requirements
Master's thesis
Approved aids for performance assessment
See study plan table

Contents
• Independent engineering work on a practice-oriented scientific project project. • Theoretical, constructive experimental tasks with detailed description and explanation of their solution. • Preparation and documentation of results in scientific form
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to • understand both technical details and interdisciplinary contexts (3) • prepare and document results in accordance with scientific and practical requirements (3) • a larger engineering project within a specified time frame (3)

Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to • analyse their own learning progress and learning needs (3) and, if necessary, derive courses of action from this (3), • working together with others in a goal-oriented manner (2), understanding their interests and social situation (2), dealing with them rationally and responsibly and communicating with them (2), and helping to shape the world of work and life (3), • working scientifically in accordance with the "rules of good scientific practice" (2), presenting specialist content (2) and presenting it to an audience using correct technical language (2).
Teaching materials provided
All manuscripts, exercises, etc. for the course of study
Teaching media
All necessary materials for working on the topics
Literature
The available state of the art
Further information on the course
Requirements for dual students: • Dual students produce a master's thesis in collaboration with their partner company. • The master's thesis, worth 26 credits, is carried out as an external project with the practice partner. • The practice partner suggests a suitable topic. • The work will be supervised by OTH Regensburg. • The final presentation of the work can also take place at the partner company.

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Module name (English name if applicable)	Module code or no.
Project thesis	PA/P1

Module coordinator	Faculty
Prof. Dr Johannes Wild	Applied Natural and Cultural Sciences

Semester according to study plan	Stage of study	Module type	Workload [ECTS credits]
1, 2, 3		Compulsory	6

Mandatory prerequisites
None
Recommended prior knowledge
Fundamentals of engineering work from a previous bachelor's degree programme

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Learning objectives: Personal competence
After successfully completing the module, students will be able to See next page

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Assigned sub-modules:

No	Name of sub-modules	Teaching scope [SWS or UE]	Workload [ECTS credits]
1.	Project work (project thesis)	4 SWS	6

Information on compulsory courses and options
Any time during the Master's programme **Requirements for dual students:** In addition to the Master's thesis, a minimum of 3 months' work experience must be completed by the end of the programme. Industrial practice must be demonstrated. This should be completed at the latest before the start of the Master's thesis at the practice partner (e.g. during the semester break). This industrial practice should be directly related to the topics of the project and Master's thesis and serves as preparation and familiarisation with the topic of the Master's thesis. For dual students , the industrial placement, project work and Master's thesis form a single unit covering a total period of at least 9 months with the industry partner, which is a special feature of the dual study model.

Submodule	**TM abbreviation**
Project thesis	**PA**

Responsible	Faculty
Prof. Dr Johannes Wild	Applied Natural and Cultural Sciences
Lecturer	Frequency
Supervising professor Professor	in every semester
Teaching format	
Project	

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	German/English	6

Time commitment:

Classroom study	Independent study
60	120

Study and examination performance
Written report
Permitted aids for performance assessment
See study plan table

Contents
In the project work, students work as part of the project or laboratory team on a specific aspect of a relevant research or development project currently underway at OTH Regensburg, e.g. a work package from a funded project. The level of the work corresponds to that of an engineer. Alternatively, the project work can be carried out in a company with supervision by a professor from the faculties of Electrical Engineering and Information Technology or Applied Natural and Cultural Sciences. The topic can be freely chosen from the existing projects. Lecturers continuously offer topics for processing. The project or laboratory manager acts as supervisor and contact person. The results of the work must be documented in an appropriate manner (optionally in English). This can also be done with a prototype, a software programme, or similar.
Description of the module: Project course on the application of nanoparticles for information technologies or sensor technology 4 SWS - 6 ECTS - Requirements: Project proposal, practical part (mandatory) and written project report Maximum number of participants: 10 Prerequisites: Students must be familiar with the basics of chemistry, i.e. have successfully completed the course "Chemistry for Engineers" or a comparable chemistry course. Learning objectives: Students are familiar with the synthesis and properties of various nanostructured materials and know examples of applications in energy generation, electrical components and sensor technology. They understand the advantages and risks of using nanoparticles. In addition, they acquire knowledge about the properties of nanostructured materials that are suitable for the aforementioned applications. After attending this course, students will understand how nanotechnology enables new concepts and applications in electrical engineering. In addition, students will develop a work plan for a scientific question and propose a suitable experimental approach to answer this question. In the practical part, students familiarise themselves with basic working procedures and characterisation techniques in a chemistry laboratory. They synthesise inorganic nanoparticles using bottom-up methods and apply the material produced in an example from microsystems technology or sensor technology. They conclude the project with a written report describing the theory behind the individual project, the experiments carried out and the results achieved. Content: This module consists of lectures (2 SWS), a practical part (2 SWS) and self-study. In addition to the lectures, students develop an individual project plan, carry out the experiments and summarise the theory and results in a project report. The lectures cover the following objectives: What are nanostructured materials? Definition and size-dependent properties Characterisation methods for nanoscale objects Plasmonic metal nanoparticles: plasmon resonance and photothermal effect, synthesis and characterisation, applications in energy generation, sensor technology and as components in conductive inks. Magnetic metal oxide nanoparticles: magnetism and superparamagnetism, synthesis and characterisation of superparamagnetic iron oxide nanoparticles (SPIONs), applications for data storage and sensor technology.

Semiconductor nanoparticles: size-dependent fluorescence, synthesis and characterisation, use of semiconductor particles in sensor technology.

Learning objectives: Professional competence

After successfully completing the sub-module, students will be able to

- apply the knowledge acquired during their studies in a specific context (2),
- plan the content of a scientific project (2) and carry it out (3)
- the project results according to the rules good scientific work and present (2).

Learning objectives: Personal competence

After successfully completing the sub-module, students will be able to

- analyse their own learning progress and learning needs (3) and, if necessary, derive courses of action from this (3),
- work together with others in a goal-oriented manner (2), understand their interests and social situation (2), deal with them rationally and responsibly and communicate with them (2), and help shape their working and living environment (3),
- work scientifically in accordance with the "rules of good scientific practice" (2), present specialist content (2) and present it to an audience using correct technical language (2).

Teaching materials provided

Project- and case-specific working documents and specialist books

Teaching media

Blackboard, notebook, projector, exhibits

Literature

- Wiesner, Hans-Jörg: "Scientific Publications: Fundamentals of Design", BeuthVerlag, 2009
- Franck, Norbert: "The Technique of Scientific Work", UTB, 2011

Further information about the course

Requirements for dual students:

- In consultation with a supervising teacher at the university, dual students work on an independent project at the cooperating company.
  university, work on an independent project at the partner company.
- The project work, worth 6 credits, must be carried out at the practice partner.
- The practice partner suggests a suitable topic.
- The work will be supervised by OTH Regensburg.
- The project work should be completed before the start of the Master's thesis.

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Module name (English name if applicable)	Module code or no.
Basic Module 1	B1

Module coordinator	Faculty
Prof. Dr. Ioana Serban Dr Gabriela Tapken (LBA)	Applied Natural and Cultural Sciences Computer Science and Mathematics

Semester according to study plan	Study section	Module type	Workload [ECTS credits]
1, 2, 3		Focus Compulsory module	8

Mandatory prerequisites
None
Recommended prior knowledge
Mathematics from bachelor's degree programmes. In particular: Fourier series, Fourier transforms, Gauss's method, Taylor's theorem, definition of derivatives, integration.

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Learning objectives: Professional competence
After successfully completing the module, students will be able to See next page
Learning objectives: Personal competence
After successfully completing the module, students will be able to See next page

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Assigned sub-modules:

No.	Name of sub-modules	Teaching scope [SWS or UE]	Workload [ECTS credits]
1.	Advanced Engineering Mathematics (Advanced Engineering Mathematics)	6 SWS	8

Information on compulsory enrolment or options
The *Higher Mathematics* course is offered in German in the winter semester (Dr Gabriela Tapken) and in English in the summer semester (Dr Michael Seidl).

Submodule	TM abbreviation
Advanced Engineering Mathematics (Advanced Engineering Mathematics)	**MM**

Responsible	Faculty
Prof. Dr. Ioana Serban	Applied Natural and Cultural Sciences
Lecturer	**Frequency**
Prof. Dr. Ioana Serban	Every semester

Teaching format
Seminar-based teaching with exercises and practical training in the computer room

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	6 SWS	German/English	8

Time commitment:

Classroom study	Independent study
150	60 hours of independent study, 30 hours of exam preparation

Coursework and examination performance
Portfolio assessment
Approved aids for performance assessment
See study plan table

Contents

- Calculation accuracy
- Condition and error checks, vector and matrix norms
- Zero point method
- Solving large linear equation systems
- Interpolation and approximation, splines
- Fourier analysis
- Non-linear optimisation
- Numerical integration
- Methods for solving ordinary and partial differential equations

Learning objectives: Professional competence

After successfully completing this submodule, students will be able to

- to estimate the magnitude of errors occurring in numerical calculations of all types covered and to identify the factors on which these errors depend. (2)
- know various known solution methods for different types of problems (1) and select a suitable method for a specific problem (2)
- list the differences and advantages/disadvantages between classical and numerical solution methods for initial value and boundary value problems (1) and, in the case of numerical solutions, select a method suitable for the task at hand (2)

- For numerical methods that are unknown to them, analyse the quality of the numerical methods in terms of their quality (3) based on known sub-areas of numerical methods.
  numerical analysis with regard to their quality (3)
- recognise the types of problems for which the use of a numerical method might or might not be appropriate. (2)

Learning objectives: Personal competence

After successfully completing the sub-module, students will be able to

- communicate about abstract matters. (2)
- Knowing what level of detail to communicate to whom. (1)
- Recognising the growing importance of mathematics for current technical and social challenges. (1)
- Evaluate results and findings obtained through numerical calculations or simulations by means of a deeper understanding of numerics, thereby achieving a responsible approach to computer-assisted science. (3)

Teaching materials offered

Gap-fill script, exercises + solutions

Teaching media

Projector, blackboard, computer

Literature

- Dahmen, D; Reusken, A: Numerics for Engineers and Scientists, Springer
  (2008) Hucke, T; Schneider, S: Numerical Methods, Springer (2006) MatLab User's Guide: Partial Differential Equation Toolbox https://www.mathworks.com/help/pdf_doc/pde/ pde.pdf (9 March 2020) Meyberg, K; Vachenauer, P: Higher Mathematics, Springer (2003) Hermann, M: Numerical Mathematics, Oldenburg (2011) Press, W; Teukolski, S; Vetterling, W; Flannery, B: Numerical Recipes, Cambridge University Press (2007) Riley, K.F.; Hobson, M.P.; Bence, S.J.: Mathematical Methods for Physics and Engineering, Cambridge University Press (2006)

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Module name (English name if applicable)	Module code or no.
Basic Module 2	B2

Module coordinator	Faculty
Prof. Dr Florian Aschauer Prof. Dr. Peter Kuczynski Prof. Dr. Rupert Schreiner Prof. Dr. Martin Schubert	Electrical Engineering and Information Technology Electrical Engineering and Information Technology Applied Natural and Cultural Sciences Electrical Engineering and Information Technology

Semester according to study plan	Study section	Module type	Workload [ECTS credits]
1, 2, 3		Focus Compulsory module	8

Mandatory prerequisites
None
Recommended prior knowledge
For MN: Fundamentals of mathematics, physics and materials For AKE: Knowledge of mathematics, physics, electronic components and circuit technology, as taught in bachelor's degree programmes in electrical engineering and information technology, microsystems technology or sensor technology and analytics. Knowledge of modules AT, DE (bachelor's degree) For AOE: Profound knowledge in engineering mathematics (calculus, partial differential equations) and college physics: mechanics, electricity, optics (bachelor's level). For PHDS: Digital Technology module

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Learning objectives: Personal competence
After successfully completing the module, students will be able to See following pages

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Assigned sub-modules:

No	Name of sub-modules	Teaching scope [SWS or UE]	Workload [ECTS credits]
1.	Advanced Optoelectronics	8 SWS	8
2.	Selected Topics of Electrical Engineering Electrical Engineering (Selected Topics of Electrical Engineering)	6 SWS	8
3.	Advanced Signal Processing	4 SWS	4
4	Micromechanics (micromachining)	6 SWS	8
5	Programmable hardware with applications in digital signal processing (Programmable Hardware with Applications in Digital Signal Processing)	4 hours per week	4

Information on compulsory enrolment or options
Supplementary regulations: One module from B 2.1 to B 2.4 must be selected. The module "Micromechanics" (MN/MT2) cannot be selected with a relevant degree programme in microsystems technology. The module "Selected Chapters of Electrical Engineering" (AKE) cannot be chosen with a relevant degree programme in electrical engineering. The module "Advanced Optoelectronics" (AOE) cannot be selected with a relevant degree programme in microsystems technology. The sub-modules "Advanced Signal Processing" (FSV) and "Programmable Hardware with Applications in Digital Signal Processing" (PHDS) form the module "Signal Processing Methods Signal Processing and its Implementations" (VSI). **Both parts** must be taken for the module must be taken for this module.

Submodule	**TM abbreviation**
Advanced Optoelectronics	**AOE**

Responsible	Faculty
Prof. Dr. Rupert Schreiner	Applied Natural and Cultural Sciences
Lecturer	Frequency
Prof. Dr. Rupert Schreiner	Winter semester only
Teaching	
Seminar-based teaching with approx. 20% practical component	

Semesters of study according to the curriculum	Scope of teaching [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	8 SWS	English	8

Time commitment:

Classroom study	Independent study
90	150

Coursework and examination
Written examination, 120 min.
Permitted aids for performance assessment
See study plan table

Contents
Part I: Fundamentals 1. Wave Optics (Propagation of Light) 1.1. Light Rays 1.2. Light waves 1.3. Light as an Electromagnetic Wave (Maxwell's Theory of EM Waves) 1.4. Dielectric waveguides 2. Photons (Emission and Detection of Light) 2.1 Discrepancies between Maxwell's Theory and Experiments 2.2 Light as a particle (photon), light-particle dualism 2.3 Emission and absorption of light 2.4 Illumination and colour perception 2.5 Optical gain and laser radiation 3. Opto-semiconductors 3.1 Energy band model; direct and indirect semiconductors 3.2 Undoped and doped opto-semiconductors 3.3 Semiconductor diode theory 3.4 Heterostructures / Technology of III-V semiconductors Part II: Applications 4. LEDs 4.1 Excess recombination 4.2 Electro-optical characteristics 4.3 Radiative and non-radiative recombination 4.4 Measures for increasing efficiency 4.5 Emission spectrum 4.6 OLED 4.7 Modulation behaviour 5. Optical amplification and semiconductor lasers 5.1 First laser condition (inversion condition) 5.2 Second laser condition (optical gain) 5.3 Technical realisation of inversion 5.4 Electro-optical characteristic in cw mode 5.5 Emission spectrum 5.6 Wavelength tunable lasers 5.7 Modulation behaviour 6. Photodetectors, solar cells and semiconductor optical modulators 6.1 Internal photoeffect 6.2 Electrical characteristics of illuminated pn junctions ("photo elements") 6.3 Solar cells 6.4 Pin photodiodes 6.5 Electro-optic modulators Part of the lecture is participation in the Microsystems Engineering Colloquium. Please refer to the enclosed list for the dates and venue The content of the lectures and the subsequent questions are part of the lecture and are relevant for the examination.
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to • After successful completion of the module, students are able to learn about the fundamentals, design, technology and operation of optoelectronic materials and modern optoelectronic devices (e.g. LEDs, semiconductor lasers, integrated optoelectronic circuits and photo-detectors). (2)

- Based on this knowledge, they should be able to read scientific publications in this field and to understand the design, the fabrication process and the operation of optoelectronic devices. (2)
- A high degree of personal contributions is expected from the master's students. The basics of optics and physics must be repeated or worked out in self-study. (2)
- to design parts of optoelectronic components and structures themselves. (3)
- To select and to choose suitable optoelectronic components for specific engineering applications. (3)
- to join in and work together with an interdisciplinary team of physicists, chemists and engineers for the fabrication of modern optoelectronic devices. (3)

Learning objectives: Personal competence

After successfully completing the sub-module, students will be able to

- After successful completion of the module, students are able to make a responsible assessment of the situation on the basis of the large number of known and available data and facts, and on this basis to make decisions and find target-oriented solutions that are in harmony with economic and ecological aspects. (2)

Teaching materials offered

Transcript, video recordings, exercises, supplemental tables and graphs.

Teaching media

Blackboard, notebook, projector

Literature

- S.M. Sze, K.K. Ng "Physics of Semiconductor Devices (3rd Ed.): Chapter 1, Chapter 12 and Chapter 13", Wiley, 2007

12 and Chapter 13”, Wiley, 2007

- D. Meschede "Gerthsen Physics", Springer, 2015

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
Selected Topics of Electrical Engineering Electrical Engineering)	**AKE**

Responsible	Faculty
Prof. Dr. Florian Aschauer Prof. Dr. Peter Kuczynski Prof. Dr. Rupert Schreiner Prof. Dr. Martin Schubert	Electrical Engineering and Information Technology
Lecturer	**Frequency**
Prof. Dr. Martin Schubert	Every semester

Teaching format
Seminar-based teaching 2/3 theory, 1/3 practical training in the lab

Semester according to the study plan	Scope of teaching [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	6 SWS	German/English	8

Time commitment:

On-site study	Independent study
84 hours campus programme	104 hours preparation and follow-up, 52 hours exam Preparation

Study and examination performance
Written examination, 120 minutes
Permitted aids for assessment
See curriculum table

Contents
Part A: Classroom: Fundamentals of electrical engineering and electronics 1. Fundamentals of electrical & electronics engineering: Kirchhoff's laws, circuits, LTI systems, etc. 2. Introduction to Laplace transform and Laplace variables and application to simple circuits 3. Working with complex impedances 4. Build passive and active filters with complex impedances 5. Fundamentals of digital filtering, translation methods s -> z, programming digital filters 6. Basic principles of electric machines 7. [Depending on time budget: The fundamental ideas of the 4 Maxwell equations] **Part B: Laboratory: Practical Training** 1. Measurement with modern equipment such as oscilloscopes and vector network analysers (Bode1) to experience the theoretical material practically in the laboratory 2. Modelling the measured data with Matlab

Learning objectives: Professional competence
After successfully completing this module, students will be able to ... • Learn (2) and understand (3) the basics of electronics • Understand (3) and apply basic analogue and digital filters. • Understand (3) the fundamental ideas of frequently used electric machines • Use (4) Matlab
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to See preamble
Teaching materials offered
Scripts, exercises, practical training, references
Teaching media
Tablet PC, projector, electronics laboratory (S081)
Literature
[1] The MathWorks, available: https://de.mathworks.com
Further information about the course
Mandatory requirements: Technical Bachelor's degree Language: Documents in English, teaching language is German or English, depending on audience.

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Advanced signal processing	**FSV**

Responsible	Faculty
Prof. Dr. Peter Kuczynski	Electrical Engineering and Information Technology
Lecturer	Frequency
Prof. Dr. Peter Kuczynski	Winter semester only
Teaching	
Seminar-based teaching with exercises	

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	German	4

Time commitment:

Classroom study	Independent study
60	60

Coursework and examination
Written examination, 90 min.
Permitted aids for assessment
See study plan table

Contents
• Increase in sampling rate (interpolation with an integer factor), special design methods for digital filters • special applications of DFT in practice (fast convolution, dual-channel DFT, spectral estimation, interpolation) • Energy signals and power signals • Fundamentals of signal processing of stochastic signals • Correlation, power density spectrum, energy density spectrum • Application of noise as a test signal or reference signal • Estimation of correlation functions in practice • Adaptive filters (Wiener filters), optimisation using the method of least mean squares, special solution methods • Applications of adaptive filters (system identification, inverse modelling, noise suppression, suppression of periodic interference, LPC analysis, speech modelling) • Wiener-Lee relations and their applications in practice • Application of Matlab and Simulink simulation programmes • Hilbert transform, analytical signal

Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to • develop and implement methods for increasing sampling rates (interpolation with an integer factor) (3) • develop, implement and evaluate selected advanced signal processing methods using DFT (3) • understand and apply the fundamental theoretical relationships of stochastic signal processing (3) • understand adaptive filters theoretically, apply them and evaluate the solution and optimisation methods (3) • understand and evaluate the mode of operation of the basic applications of adaptive filters (3). • understand the theory of Hilbert transformation and know its application (3) • understand and apply linear prediction for encoding speech signals (3) • Implement and evaluate the theoretically discussed methods of advanced signal processing using MATLAB and Simulink (3)
Teaching materials provided
Handouts for the lecture
Teaching media
Overhead projector, blackboard, computer/projector
Literature
Oppenheim, Schafer: Discrete Time Signal Processing, Prentice Hall 1989
Further information about the course
The course is part of module B2.4: *Methods of Signal Processing and their Implementations*

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Micromachining	**MT**

Responsible	Faculty
Prof. Dr. Rupert Schreiner	Applied Natural and Cultural Sciences
Lecturer	Frequency
Prof. Dr. Rupert Schreiner	Summer semester only
Teaching	
Seminar-based teaching with approx. 20% practical component	

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	6 SWS	German	8

Time commitment:

Classroom study	Independent study
90	150

Coursework and examination
Written examination, 90 minutes
Permitted aids for assessment
See study plan table

Contents
I. Continuum mechanics: 1) Elasticity: Isotropic solids, anisotropic solids 2) Effects of mechanical-electrical signal conversion: piezoelectric effect, piezoresistive effect 3) Analytical approximate solutions of elasticity theory for special cases: Method for determining the mechanical stress of a thin layer on a round substrate, deformation of an isotropic rectangular thin plate, thin plate clamped on one side (bending beam), thin plate clamped on all sides (membrane). II. Introduction to microtechnology with silicon and III-V semiconductors 1) Materials in microtechnology: material types, technologies, influence of crystal structure on structuring possibilities 2) Anisotropic wet chemical etching of silicon and III-V semiconductors: anisotropic wet etching solutions, concentration and temperature dependence, position of crystal planes relative to the wafer surface, edge etch rates on wafer surfaces, etch geometries for given etch mask geometries, etch geometries for hole-like structures after long etch times, compensation structures for protecting convex corners, etch stop layers 3) Dry etching processes: Mode of operation, mean free path, anisotropy and selectivity, plasma and barrel etching, sputter and ion beam etching, RIBE and CAIBE, reactive ion etching (RIE), DRIE, increasing anisotropy through sidewall passivation III. Colloquium on microsystems technology (4 lectures)
Learning objectives: Professional competence
After successfully completing the submodule, students will be able to • Knowledge of the fundamental mechanical/physical properties of Si and III/V-HL (1). • Apply this knowledge to the design and manufacture of semiconductor-based microsystems, components and microstructures (3). • Apply theoretical background knowledge to realise the structures in practice (3). • Master's students are expected to demonstrate a high level of independent work, as they must acquire the missing fundamentals in semiconductor technology and physics through self-study. • Independent dimensioning and design of microstructures for applications in semiconductor technology (3). • Independent design of process sequences for the manufacture of structures and components (3).
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to • Based on the multitude of known and available data and facts, make a responsible assessment of the situation and, on this basis, make decisions and find targeted solutions that are in line with economic and ecological aspects. (2)

Teaching materials offered
Transcripts, instructional videos, exercises with solutions, supplementary diagrams and tables
Teaching media
Blackboard, notebook, projector
Literature
• Mescheder Ulrich: Microsystems Technology, Teubner, Stuttgart, 2nd edition, 2004 (Micromechanics and Technology) • Robert E. Newnham: Properties of materials – Anisotropy, Symmetry, Structure, Oxford University Press, New York, 2005 (continuum mechanics, detailed) • Gerlach G., Dötzel W.: Introduction to Microsystems Technology, Hanser, 2006 (very concise but comprehensive, many applications, detailed derivations of continuum mechanics, tensor calculus in the appendix) • Volklein F., Zetterer T.: Practical Knowledge of Microsystems Technology, Vieweg, 2nd edition 2006 (comprehensive, few derivations, but many applications)
Further information on the course
Recommended prior knowledge: Fundamentals of mathematics, physics and materials

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Programmable hardware with applications in digital signal processing ( ) signal processing (Programmable Hardware with Applications in Digital Signal Processing)	**PHDS**

Responsible	Faculty
Prof. Dr. Florian Aschauer	Electrical Engineering and Information Technology
Lecturer	Frequency
Prof. Dr. Florian Aschauer	Winter semester only
Teaching	
Seminar-based teaching with exercises	

Semester according to study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1, 2, 3	4 SWS	German	4

Time commitment:

Classroom study	Independent study
30	60 hours of preparation and follow-up work, 30 hours Exam preparation

Study and examination performance
Practical performance assessment
Permitted aids for performance assessment
See study plan table

Contents

10 double lessons of seminar-based teaching:

- Programmable components
- PLD: Programmable Logic Device, CPLD: Complex Programmable Logic Device, FPGA: Field Programmable Gate Array, ARTIX-7 architecture
- Introduction to VHDL
- Hardware basics
- Spikes, synchronous Logic, Finite State Machines, Systematic design of complex digital circuits, AXI-Lite interface

20 double lessons of laboratory practice:

- Hardware basis: NEXYS4 FPGA development board
- Joint tasks:
- Familiarisation with the VIVADO development system (XILINX Inc.)
- Combinational 7-segment decoder
- 7-segment decoder multiplex
- Register reader AXI interface
- Application of the "register reader" for communication with a UART interface
- Individual projects Projects, e.g.:
- Control of 16-bit DA converter SPI PMOD DA3
- Test bench for PMODDA3 SPI output -> analogue representation
- Control of dual 12-bit DA converter SPI PMOD DA2
- DA conversion via PWM output
- AD converter on-chip AXI Lite interface
- AXI register writer
- FIR filter parallel
- FIR filter serial
- Data shift register with storage in block RAM
- Further projects as required

Learning objectives: Technical expertise

After successfully completing the submodule, students will be able to

- Implement basic hardware constructs with associated VHDL descriptions. (1)
- Master the use of the VIVADO design software. (2)
- have an overview of the toolchain, operation of the VHDL editor, simulator, synthesis and hardware download. (2)
- Independently design complex digital circuits based on VHDL/FPGA. (3)
- To create timing planning, RTL partitioning, VHDL coding, verification and documentation. (3)

Learning objectives: Personal competence

After successfully completing the submodule, students will be able to

- analyse one's own learning progress and learning needs (3) and, if necessary, derive courses of action from this (3),

- to work together with others in a goal-oriented manner (2), to understand their interests and social situation
  (2), dealing with them rationally and responsibly and communicating with them (2), as well as helping to shape the world of work and life (3),
- working scientifically in accordance with the "rules of good scientific practice" (2), presenting specialist content (2) and presenting it to an audience using correct technical language (2).

Teaching materials provided

Gap-fill script, instructions for laboratory exercises, design examples, bibliography

Teaching media

Computer workstation with VIVADO design software, NEXYS4 FPGA development board, test benches, measuring devices

Literature

- Wakerly, John F.: "Digital Design, Principles and Practices", New Jersey: Prentice Hall 2005
- Mano, M. Morris: "Computer System Architecture", New Jersey: Prentice Hall 1993
- Hodges, D. A., Jackson, H. G.: "Analysis and Design of Digital Integrated Circuits", New York: McGraw Hill 2003
- XILINX Inc.: HighLevel Synthesis: UG871 (v2016.1) 6 April 2016
- XILINX Inc.: Vivado Design Suite User Guide: Synthesis: UG901 (v2016.1) 1 April 2015
- XILINX Inc.: UltraFast Design Methodology Guide for the Vivado Design Suite
- Digilent Inc.: Nexys4™ FPGA Board Reference Manual, DOC#:502-274 , rev. B; Revised 19 November 2013

Further information about the course

The course is part of module B2.4: *Methods of Signal Processing and their Implementations*

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Module name (English name if applicable)	Module code or no.
Basic Module 3	B 3

Module coordinator	Faculty
Prof. Dr. Florian Aschauer Prof. Dr. Norbert Balbierer Prof. Dr. Peter Bickel Prof. Dr. Corinna Kaulen	Electrical Engineering and Information Technology Electrical Engineering and Information Technology Applied Natural and Cultural Sciences Applied Natural and Cultural Sciences

Semesters of study according to the study plan	Study section	Module type	Workload [ECTS credits]
1, 2, 3		Focus Compulsory module	5

Mandatory prerequisites
None
Recommended prior knowledge
For DT2: Fundamentals of digital technology; in particular number systems, Boolean algebra, switching networks, KV diagrams, simple counter circuits; knowledge of digital technology modules For CI: Materials For LT: Basic Physics lectures (TP1, TP2), Electrodynamics, Maxwell equations, Planck black body radiation, Basic facts of solid state physics, Linear algebra, matrix and vector calculus, Technical Optics For NES: Digital technology, microcomputers, computer science, automation systems

Contents
See following pages

Learning objectives: Professional competence
After successfully completing the module, students will be able to See following pages
Learning objectives: Personal competence
After successfully completing the module, students will be able to See following pages

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Assigned sub-modules:

No.	Name of sub-modules	Teaching scope [SWS or UE]	Workload [ECTS credits]
1.	Chemistry for Engineers (Engineering Chemistry)	4 SWS	5
2.	Digital Technology 2 (Digital Design 2)	4 SWS	5
3	Networks for Embedded Systems (Networks for Embedded Systems)	4 SWS	5
4	Photonics and Laser Technology	4 SWS	5

Information on compulsory enrolment or options
Supplementary regulations: One module from B 3.1 to B 3.4 must be selected. The Chemistry for Engineers (CI) module cannot be selected in conjunction with a relevant degree programme in microsystems technology or sensor technology and analytics. The module Digital Technology 2 (DT2) cannot be selected with a relevant degree programme in electrical engineering. The module "Photonics and Laser" (LT) cannot be selected if it has already been taken in the OTHR Bachelor's degree programme in Microsystems Technology.

Submodule	**TM abbreviation**
Chemistry for Engineers (Engineering Chemistry)	**CI**

Responsible	Faculty
Prof. Dr. Corinna Kaulen	Applied Natural and Cultural Sciences
Lecturer	Frequency
Prof. Dr. Corinna Kaulen	Summer semester only
Teaching format	
Seminar-based teaching Lectures and practical lessons	

Semester according to study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1, 2, 3	4 SWS	English	5

Time commitment:

Classroom study	Independent study
60	90

Coursework and examination
Written examination, 90 min.
Approved aids for performance assessment
See study plan table

Contents

- Structure of matter: elements, compounds, states of matter, atomic structure and
  Periodic table of elements, masses and quantities
- State behaviour and gas laws, fundamentals of thermodynamics
- Concepts of chemical bonding: covalent, metallic and ionic bonding, oxidation numbers and intermolecular interactions
- Fundamentals of chemical reactions: stoichiometry, chemical equilibrium, acid-base reactions, redox reactions
- Electrochemistry: galvanic cells, electrodes, electrolysis

- The structure of matter: elements, compounds, states of matter, atomic structure and periodic table of the elements, masses and quantities
- State behaviour and gas laws, basics of thermodynamics
- Concepts of chemical bonding: covalent, metallic, and ionic bonding, oxidation numbers and intermolecular interactions
- Fundamentals of chemical reactions: stoichiometry, chemical equilibrium, acid-base reactions, redox reactions Electrochemistry: galvanic elements, electrodes, electrolysis

Learning objectives: Professional competence
After successfully completing this sub-module, students will be able to • describe the atomic and molecular structure of matter (1) and apply this knowledge to specific questions (2) • predict the behaviour of substances under different conditions (3) • analyse energy relationships in chemical reactions and determine energy conversion (2) • understand and predict the principles of material changes and the chemical behaviour of important substances (3) • distinguish between acids and bases and calculate the pH values of aqueous solutions of acids and bases (2) • Determine the oxidation numbers of chemical compounds and set up redox equations (2) • Describe an electrochemical cell (1), calculate the terminal voltage (2) and know the factors that influence the terminal voltage (1) • You know various concepts electrical energy into chemical energy (1) • They can determine and classify physical quantities such as pH value, energy conversion and state variables of systems (3)
• produce the atomic and molecular structure of matter (1) and apply it to specific problems (2) • predict the state behaviour of substances (3) • analyse energy ratios in chemical reactions and determine the energy conversion (2) • understand and predict the principles of material changes and the chemical behaviour of important substances (3) • differentiate between acids and bases and calculate the pH values of aqueous solutions of acids and bases (2) • determine the oxidation numbers of chemical compounds and set up redox equations (2) • describe an electrochemical element (1), calculate the electromotive force of an electrochemical element (2) and know the influences on the electromotive force (1) • know different concepts for converting electrical energy into chemical energy (1) • can determine and classify physical quantities such as pH value, energy conversion and state variables of systems (3)
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to • acquire scientific working methods (3) • act independently and responsibly (3) • work in a goal-oriented manner and analyse their own learning progress and learning needs (3) • discuss scientific issues (2) • recognise the relevance of chemistry in everyday issues and evaluate them based on facts (3)
• to adopt the scientific way of working (3) • act independently and responsibly (3) • work focused and analyse their own learning progress and learning needs (3)

- exchange ideas and discuss scientific issues (2) recognise the connection to chemistry in everyday questions and evaluate them based on facts (3)

Teaching materials provided
Script, set of exercises, slides
Teaching media
Blackboard, projector, e-tests
Literature

- Chemistry, C. E. Mortimer, J. Beck, U. Müller, Thieme (2015)
- Chemistry – The Central Science, T. L. Brown, H. E. Le May, B. E. Bursten, Prentice Hall (2006)
- Chemistry, C. Housecroft, C. Constable, Prentice Hall (2006)

The numbers in brackets indicate the levels to be achieved: 1 – know, 2 – can, 3 – understand and apply

Submodule	**TM abbreviation**
Digital Technology 2 (Digital Design 2)	**DT2**

Responsible	Faculty
Prof. Dr Florian Aschauer	Electrical Engineering and Information Technology
Lecturer	Frequency
Prof. Dr. Florian Aschauer	Summer semester only
Teaching	
Seminar-based teaching with exercises	

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	German	5

Time commitment:

Classroom study	Independent study
56	62 hours of preparation and follow-up work, 32 hours Exam preparation

Coursework and examination
Written examination, 90 min.
Permitted aids for assessment
See study plan table

Contents

Basic CMOS circuits combinational

- Inverters, NAND, NOR, complex gates

Basic sequential CMOS circuits

- Latch, D flip-flop, register, shift register, various universal registers

Basic bipolar circuits, combinational

- Basic principle of ECL circuit technology, OR/NOR

Complex basic functions; adders, multipliers

- Half adder, full adder, carry look ahead
- Implementation of adder stages as complex gates
- Ripple carry multiplier, carry save multiplier, serial multiplier

Finite state machines

- Moore-Mealy machine
- Design using state tables
- Design using state diagram
- Design using hardware description languages

Introduction to the hardware description language VHDL

- Language elements Concurrent and Sequential
- Coding examples of the basic blocks

Systematic design of complex digital systems

- Register planning
- Timing planning with spreadsheets
- Application example: RS232 interface - Application example: SPI interface

Learning objectives: Professional competence

After successfully completing the submodule, students will be able to

- specify the basic circuits of digital microelectronics (1)
- name the basic blocks of complex systems (1)
- to carry out the circuit design of digital circuits based on FPGA or ASIC (2)
- generate the system design of digital circuits based on FPGA or ASIC (2)
- Systematically design complex digital systems at gate and register transfer level using hardware description languages (3)
- assess the feasibility of digital systems (3)
- Divide complex projects into sub-projects, define sub-specifications and interfaces (3)

Learning objectives: Personal competence

After successfully completing the sub-module, students will be able to

- analyse their own learning progress and learning needs (3) and, if necessary, derive courses of action from this (3),
- working together with others in a goal-oriented manner (2), understanding their interests and social situation (2), dealing with them rationally and responsibly and communicating with them (2), and helping to shape the world of work and life (3),
- working scientifically in accordance with the "rules of good scientific practice" (2), presenting specialist content (2) and presenting it to an audience using correct technical language (2).

Teaching materials

Graphics tablet, gap-fill script PDF, PDF annotator, computer/projector, simulation software, blackboard

Literature

- Weste, Eshragian: "Principles of CMOS VLSI Design, A Systems Perspective, Massachusetts: Addison-Wesley 1993
- Wakerly, John F.: Digital Design, Principles and Practices, New Jersey: Prentice Hall 2005 Mano,
- M. Morris: Computer System Architecture, New Jersey: Prentice Hall 1993
- Hodges, D. A., Jackson, H. G.: Analysis and Design of Digital Integrated Circuits, New York: McGraw Hill 2003
- Mead, C., Conway, L.: Introduction to VLSI Systems, Massachusetts: Addison-Wesley 1980
- Klar, H.: "Integrated Digital Circuits MOS/BICMOS", Springer Verlag: Berlin 1996
- Navabi, Zainalabedin: "VHDL Analysis and Modelling of Digital Systems", New York: McGraw Hill 1993

Further information about the course

Recommended prior knowledge:
Digital technology module; number systems, Boolean algebra, switching networks, KV diagram, simple counter circuits

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
Networks for Embedded Systems (Networks for Embedded Systems)	**NES/B3.4**

Responsible	Faculty
Prof. Dr. Norbert Balbierer	Electrical Engineering and Information Technology
Lecturer	**Frequency**
Prof. Dr. Norbert Balbierer	Summer semester only

Teaching format
Seminar-based teaching, exercises, practical component > 10%

Semesters of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1, 2, 3	4 SWS	German	5

Time commitment:

Classroom study	Independent study
60	90

Coursework and examination
Written examination, 90 minutes
Permitted aids for assessment
See study plan table

Contents

- Fundamentals of computer networks and bus systems
- ISO/OSI layer model
- What are fieldbuses?
- Fundamentals of CAN, Ethernet, Ethernet TSN
- Fundamentals of real-time capability and quality of service
- Time synchronisation, reservation procedures and traffic shaping
- Examples and exercises accompanying the lecture

Learning objectives: Professional competence

After successfully completing the sub-module, students will be able to

- understand fieldbuses and networks and their areas of application and select suitable systems (2)
- Understanding network technology (layers 1 and 2) (2)
- Know the requirements of different areas of application for networks and buses (1)
- Understand the basics of CAN bus and be able to use it (3)
- Understand the fundamentals of 802.3 Ethernet and be able to use it (3)
- Be able to evaluate networks and buses in terms of real-time capability and quality of service (2)
- Know mechanisms (802.1) for implementing real-time capability and quality of service in Ethernet (1)

Teaching materials provided
Lecture notes/blackboard, Linux man pages, textbooks, configuration files and programmes
Teaching media
Computer/projector, blackboard, examples with Ethernet- and CAN-compatible hardware (Raspberry Pi, STM32H743, ESP32 or similar)
Literature
• Andrew S. Tanenbaum, Computer Networks, Pearson • James Kurose & Keith Ross, Computer Networks: The Top-Down Approach, Pearson
Further information about the course
Independent study: 48 hours (preparation and follow-up work for lectures), 16 hours (exam preparation)

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Photonics and Laser Technology	**LT**

Responsible	Faculty
Prof. Dr Peter Bickel	Applied Natural and Cultural Sciences
Lecturer	Frequency
Prof. Dr. Peter Bickel	Winter semester only
Teaching	
Seminar-based teaching with exercises	

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 hours per week	English	5

Time commitment:

Classroom study	Independent study
60	90

Coursework and examination
Written examination, 90 minutes
Permitted aids for assessment
See study plan table

Contents
1) Characterisation of light, temporal and spatial coherence, photon statistics and blackbody radiator, Planck's law, sources of radiation 2) Interaction of electromagnetic waves with atomic systems, radiation field, emission and absorption of electromagnetic radiation, spontaneous and induced emission, two-level system, thermal equilibrium, population density balance 3) Spectral lines and line shape, spectral line broadening 4) Physical elements of lasers, Storage of light: Resonator types and their geometry, Losses in resonators, optical resonator modes, Wavelength and mode selection, principle of Quality switching 5) The laser principle Creation of a population inversion, three and four level system, amplification of light and feedback, theoretical efficiency of lasers, threshold condition, bandwidth and mode spectrum, dynamics of laser systems 6) Beam propagation, The Gauss beam, Focusing of laser beams, Atmospheric transmission and turbulence 7) Examples of real laser systems, gas lasers: CO2 laser, excimer laser, HeNe laser, Ar-ion laser, diode lasers, solid-state lasers: NdYag laser, ErYag laser, diode-pumped solid-state lasers, dye lasers 8) Technical aspects of optical elements used in lasers, metal mirrors versus dielectric mirrors, Brewster plates, electro-optical active elements, Pockels and Kerr cells, polarizers, beam steering elements – laser optics, technical aspects of Q-switch, short pulse creation: ps and fs lasers 9) Laser beam material interaction, dielectric function, absorption and reflection, plasma formation, plate frequency ... 10) Micro machining with lasers 11) Lasers for measuring, distance measurement, interferometry, etc. 12) Applications: Medical applications, CD players, laser gyros, etc. 13) Safety – Laser hazards
Learning objectives: Professional competence
After successfully completing this sub-module, students will be able to • Understand the properties of electromagnetic waves and radiation (1) • Understand basic physics and theory of laser operation. (2) • Knowledge of technical elements of lasers (3) • Handling laser beam propagation (2) • Knowledge of the most popular lasers and their application (1) • Understanding basic physics of laser material interaction (1) • Laser applications in machining, medicine and measurement (2) • Understanding the hazards of laser operation (2)
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to • After taking part successfully in the course, the attendant should be able to design a laser system and perform all necessary basic calculations for it, e.g. performance data like divergence, output power estimation, Gaussian beam characterisation, resonator layout The ability to choose an adequate laser system for a specific material processing task. -Responsibility in handling laser hazards and maintaining eye safety

Teaching materials offered
Script is available in English
Teaching media
Board, notebook, projector, experiments
Literature

Literature for laser basics:

- Weber, Herziger: "Laser" Fundamentals and Applications, Physik Verlag, Weinheim
- F.K. Kneubühl / M.W. Sigrist: "Laser", Teubner Study Books, B.G. Teubner Stuttgart
- N. Hodgeson, H.Weber: "Optical Resonators", Springer Verlag
- A. Yariv: "Optical Electronics", Saunders College publishing, 1991
- J. Hawkes, I. Latimer: "Lasers, Theory and Practice", Prentice Hall, 1995 / ISBN 0-13-521493-9
- A.E. Siegman: “Lasers”, Oxford University Press, 1986
- H. Haken: “Laser Theory”, Springer, Berlin, 1985
- B.E.A. Saleh, M.C. Teich: Fundamentals of Photonics; Wiley, 1991
- P.W. Milonni, J.H. Eberly: Lasers; Wiley, 1988

Special lasers:

- W. Koechner: “Solid state laser engineering”, Springer series in Opt. Sci., Berlin 1988
- W.J. Witteman: "The CO2 Laser", Springer Verlag

Laser material interaction:

- Martin von Allmen: “Laser-Beam Interactions with Materials” Springer Verlag
- P. Gibbon: "Short Pulse Laser Interactions with Matter"; Imperial College Press, 2005

Optics:

- Max Born and Emil Wolf: "Principles of Optics", Pergamon Press / ISBN 0-08-018018 3.

This is the standard reference for classical optics. It should be a part of every optics library. Although it does not deal with computer algorithms or numerical analysis, it covers most of the optical principles used in

- F.L. Pedrotti, S.J. Leno Pedrotti: "Introduction to Optics", Prentice Hall, New Jersey, 1987 / ISBN 0-13-501545-6
- K.D. Moeller: “Optics”, University science books, Mill Valley California, 1988 / ISBN 0-935702-145-8

Nonlinear optics:

- R.W. Boyd: Nonlinear Optics; Academic Press, 2nd edition, 2003
- Y.R. Shen: Principles of Nonlinear Optics; Wiley, 1984
- P.N. Butcher, D. Cotter: The Elements of Nonlinear Optics; Wiley 1984
- D.L. Mills: Nonlinear Optics; Springer 1999
- M. Schubert, B. Wilhelmi: Nonlinear Optics and Quantum Electronics; Wiley 1986

Further information about the course
We will visit the "Photonics" laboratory for laser experiments.

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Module name (English name if applicable)	Module code or no.
Basic Module 4	B 4

Module coordinator	Faculty
Prof. Dr. Peter Bickel Prof. Dr. Franz Graf Prof. Dr. Rupert Schreiner	Applied Natural and Cultural Sciences Electrical Engineering and Information Technology Applied Natural and Cultural Sciences

Semester according to study plan	Study section	Module type	Workload [ECTS credits]
1st, 2nd, 3rd		Focus Compulsory module	5

Mandatory prerequisites
None
Recommended prior knowledge
For FK 2: General physics and mathematics For MC: Digital technology, circuit technology, basics of programming in C or C++ For TOM: Mathematics (vector analysis, differential and integral calculus, complex numbers, Fourier transformation) and physics (engineering optics), microtechnology (microfabrication)

Contents
See following pages

Learning objectives: Personal competence
After successfully completing the module, students will be able to See following pages

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Assigned sub-modules:

No.	Designation of submodules	Scope of teaching [SWS or UE]	Workload [ECTS credits]
1.	Microcontrollers	4 SWS	5
2	Applied Optics	4 SWS	5

Information on compulsory enrolment or options
Supplementary regulations: One module from B 4.1 to B 4.3 must be selected. The Solid State Physics 2 (FK 2) module cannot be selected with a relevant degree programme in microsystems technology.

The Microcomputer Technology (MC) module cannot be selected with a relevant degree programme in Electrical Engineering.

Submodule	**TM abbreviation**
Microc o n t rollers	**MC**

Responsible	Faculty
Prof. Dr. Norbert Balbierer	Electrical Engineering and Information Technology
Lecturer	**Frequency**
Prof. Dr. Norbert Balbierer Prof. Dr. Detlef Jantz	Every semester
Teaching format	
Seminar-based teaching, laboratory exercises, practical component > 30%	

Semesters of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1, 2, 3	4 SWS	German/English	5

Time commitment:

Classroom study	Independent study
60	90

Coursework and examination
Written examination, 90 minutes
Permitted aids for assessment
See study plan table

Contents

Computer architectures and memory

– Hardware-oriented programming of the ARM Cortex-M processor in assembler and C

- Overview of the ARM Cortex-M3/M4
- Memory organisation, pipeline, stack, clock
- Instruction set
- Subroutines, macros and interrupts
- Development environment
- Software creation process (compiler, assembler, linker)
- Finite automata

– Peripherals

- GPIOs
- SysTick and GPT timers
- A/D converters
- Serial interfaces (UART, SPI, I2C)

– Laboratory exercises accompanying lectures with ARM Cortex-M3/4

- Getting to know the toolchain (Keil, GNU arm-none-eabi)
- Programming in Assembler and C
- Debugging and troubleshooting - Possible independent work with eval boards and in the laboratory

Possible independent work with evaluation boards and in the laboratory

Learning objectives: Professional competence

After successfully completing the submodule, students will be able to

- understand and apply the functioning of processors and microcontrollers (3)
- understand and develop assembler programmes for ARM instruction sets (3)
- document code appropriately (flowcharts, comments) (2)
- Perform hardware-related programming in Assembler and C
- Be able to work with interrupt systems (2)
- Know how peripheral drivers work (1)
- Know how to divide complex (programming) tasks into modules and interfaces (1)

Learning objectives: Personal competence

After successfully completing the sub-module, students will be able to

- With technical documents (e.g. data sheets, reference manuals) (2)
- Know technical English vocabulary (1)

Teaching materials provided

Lecture notes, English-language reference manuals (ARM Cortex-M), textbooks, sample programmes in Assembler and C

Teaching media
Computer/projector, blackboard, evaluation boards and logic analysers, webcam
Literature
• J. Yiu, The Definitive Guide to the ARM Cortex-M3, Elsevier 2010 • H. Meier, Microcomputer Technology, Lecture Notes, OTH Regensburg • F. Graf, Microcomputer Technology, Lecture Notes, OTH Regensburg • N. Balbierer, Microcomputer Technology, Lecture Notes, OTH Regensburg • ARM, ARMv7-M Architecture Reference Manual, company publication • ARM, ARM Cortex-M4 Technical Reference Manual, company publication • ARM, Procedure Call Standard for the ARM Architecture, company publication • J. Valvano, Introduction to ARM Cortex-M Microcontrollers Vol. 1, 2015
Further information about the course
Recommended prior knowledge: For the Microcomputer Technology lecture: Computer Science 1 (C programming)

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Applied Optics	**AO**

Responsible	Faculty
Prof. Dr Peter Bickel	Applied Natural and Cultural Sciences
Lecturer	Frequency
Prof. Dr. Peter Bickel	Summer semester only
Teaching	
Seminar-based teaching; 15 to 25% practical component	

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	English	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
Written examination, 90 minutes
Permitted aids for assessment
See study plan table

Contents

Elements of Mathematics

- Complex numbers (mathematical representation of travelling waves)
- Fourier transformation (complex notation, basic Fourier rules)
- Wave equation

Essential Optics

- Physics of Light (Maxwell equation, boundary conditions, wave propagation, electromagnetic waves, polarisation, plane waves, wavefronts, Gaussian beam (paraxial wave equation), energy (pointing vector), free-space and waveguide propagation)
- Optical Materials (refractive index, polarizability, atomic susceptibility, Lorentz Oscillator Model, dispersion, attenuation, glass, semiconductors, other materials)
- Optical interfaces (reflection and refraction, Fresnel equations, power transmission and reflection, internal reflection, evanescent field, optical multilayer coatings)

Microoptics

- Reflective Microoptics (reflection, planar mirrors, nonplanar mirrors, micromirrors)
- Refractive Microoptics (lens fundamentals, imaging, Gaussian optics, primary aberrations, chromatic aberrations, microlenses, planar GRIN microlenses, GRIN rod lenses, ball lenses, micro-Fresnel lenses)
- Diffractive microoptics (diffraction, Fresnel-Krichhoff formula, practical apertures, gratings, diffractive microlenses)
- Guided-wave microoptics (waveguides, ray-optic model, electromagnetic model, integrated waveguide optics, waveguide characterisation, waveguide components, optical fibres)

Microoptical Fabrication

- Basic Semiconductor Processing (lithography, deposition, etching, assembly)
- Fabrication of microlenses (self-assembly lenses, microcontact printing, lithography for microlenses)
- MEMS fabrication (bulk micromachining, surface micromachining, deep reactive ion etching of silicon, LIGA process, micro-moulding techniques)

Compound and Integrated Free-Space Optics

- Microoptical imaging (multi-aperture imaging, space-bandwidth product, microoptical imaging for interconnection, guiding of high-power beams)
- Integrated free-space optics (MEMS-based integrated free-space optics, stacked planar optics, planar integrated free-space optics, and design of free-space optical systems)

Learning objectives: Professional competence

After successfully completing the sub-module, students will be able to

Knowledge:

- Knowledge about the physical background and the key areas of microoptics
- Knowledge of the topics basic optics, optical materials, refraction,
- diffraction, micro mirrors, micro lenses and guided-wave micro optics.
- Knowledge about the fabrication technique of micromechanical components

- Knowledge about the function, design and realisation of compound and integrated free space optics

Skills:

- Correct use of technical terms,
- Correct application of the introduced methods

Competences:

- Correct application of the introduced formulas to problems in microoptics

Teaching materials

Blackboard, notebook, projector, etc.

Literature

- Hans Zappe: Micro-Optics, Cambridge University Press, Cambridge (UK), (2010)
- Jürgen Jahns, Stefan Helfert, Introduction to Micro and Nanooptics, WILEY-VCH GmbH & Co. KGaA, Weinheim (Germany) (2012)
- Stefan Sinzinger, Jürgen Jahns, Microoptics, WILEY-VCH GmbH & Co. KGaA, Weinheim (Germany) (2003)

Optics in common:

- Eugene Hecht. "Optics", Addison Wesley, San Francisco, 2002, ISBN 0-8053- 8566-5
- F.L. Pedrotti, S.J. Leno Pedrotti: "Introduction to optics", Prentice Hall, New Jersey, 1987, ISBN 0-13- 501545-6
- K.D. Moeller: Optics, University Science Books, Mill Valley, California, 1988, ISBN 0-935702-145-8
- Bergmann, Schäfer “Textbook of Experimental Physics” Volume III, Optics, Walter de Gruyter Verlag
- Max Born and Emil Wolf, Principles of Optics, Pergamon Press, ISBN 0-08-0180183.

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Module name (English name if applicable)	Module code or no.
Digitalisation Competencies in Engineering Sciences (DC)	DC/I 3

Module coordinator	Faculty
Prof. Christophe Barlieb	Architecture
Prof. Dr. Markus Goldhacker	Mechanical Engineering
Prof. Dr. Thomas Kriza	Applied Natural and Cultural Sciences
Prof. Florian Weininger	Civil Engineering

Semester according to study plan	Study section	Module type	Workload [ECTS credits]
1, 2, 3		Focus Elective module	12

Assigned sub-modules:

No.	Name of submodules	Teaching scope [SWS or UE]	Workload [ECTS credits]
1.	Applied Robotics - Basics	4 SWS	5
2	Cobots and additive manufacturing	4 SWS	5
3	Cybercraft Archive: Augmented Reality Crafting	4 SWS	5
4.	Digitalisation and Ethics (Digitalisation and Ethics)	2 SWS	2
5	Cognitive Systems (Cognitive Systems)	4 SWS	5

Submodule	TM abbreviation
Applied Robotics - Basics	**RSDS_Rob**

Responsible	Faculty
Prof. Dr. Thomas Linner	Civil Engineering
Lecturer	Frequency
Prof. Dr. Thomas Linner	Every semester

Teaching style
Seminar-style instruction with lectures and practical exercises (SU

Semester of study according to the curriculum	Scope of teaching [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	German/English	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
Portfolio examination Written exam, 60 min. (subject fundamentals, at the end of the semester) + short presentations (during the semester, as part of the integrated project exercises
Permitted aids for performance assessment
see study plan

Contents

Subject Foundations (Knowledge/Skills):

- What is a robot and what distinguishes robots from other machines and systems?
- Robot typology and use cases in key areas of life and industry: manufacturing, work environments, healthcare and medical technology, construction and agriculture, mobility, smart cities, etc.
- Basics of robot construction: joints, links, motors/drive systems, sensors, end effectors & tooling, robot peripherals, work kinematics, control and regulation technology (sensing, perception-planning, control), etc.
- Basics of robot programming, configuration, and programming using various tools (CAD, visual and textual programming, frameworks, etc.)
- Fundamentals of human-robot collaboration
- Approaches for structuring robot peripherals (processes, environment, etc.) for seamless integration of robots
- System-of-systems engineering: integration of robotics into higher-level systems (e.g., smart cities, distributed robotics, etc.). How to design, develop, and implement robotic applications?
- Perspectives on robotics: mechanical engineering, computer science, electrical engineering, ergonomics, product design, innovation in companies, etc.
- Human factors: acceptance, ethics, legal framework, privacy

Integrated Practical Project (Understanding and Application):

- Multi-disciplinary topics from the field of applied robotics at the interface of research and application (through companies, research projects, etc.)
- Team-based collaboration in highly interdisciplinary development teams
- Multidisciplinary system development using structured development methods and approaches
- Analysis and formal/digital representation of aspects such as stakeholder context, usage scenarios, and system requirements
- Systematic verification/validation
- Hands-on practice and implementation in the lab (simulations, models, mock-ups, etc.)

Notes:

- The course is suitable for both beginners without programming/robotics knowledge and advanced students with strong programming skills. The focus is on the application integration of robotics and robotic subsystems.
- The integrated practical project is primarily intended to be worked on during in-person sessions.

Learning objectives: Professional competence

After successfully completing the submodule, students will be able to

- Understand methods, technologies, and systems and grasp technical terms of robotics in a multidisciplinary context (2).
- Understand basic use cases for robotics in various application fields and be able to formulate them accurately (2).
- Be familiar with integrated solutions (from digital models to robot control) for partial tasks/systems (1).

- Strategically plan and implement the (further) development or integration of a technology-based solution into an application case or system context (3).

Learning objectives: Personal competence

After successfully completing the sub-module, students will be able to
- Assess their own knowledge in relation to the subject area and continuously develop it (2).
- Evaluate the opportunities and risks of robotics, also considering non-technical factors (ecological, economic, legal context, ethical, etc.) (2).
- Contribute their skills and approaches in a goal-oriented manner to multidisciplinary teams (3).

Literature

Will be announced during class.

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Cobots and additive manufacturing	**CCK_AR-P**

Responsible	Faculty
Prof. Dr. Thomas Linner	Civil Engineering
Lecturer	Frequency
N.N.	Every semester
Teaching format	
Seminar-based teaching	

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1, 2, 3	4 SWS	German/English	5

Time commitment:

Classroom study	Independent study
60	90

Coursework and examination
Portfolio assessment Portfolio review: Written exam, 60 min. (subject fundamentals, at the end of the semester) + Short presentations (during the semester, as part of the integrated project exercises)
Permitted aids for performance assessment
see study plan

Contents

In-depth multidisciplinary topics in collaboration with industry partners:

- Human-robot collaboration and collaborative robots in craftsmanship and new robotic application fields with a human-centred focus outside conventional manufacturing industries.
- Collaborative robotic systems: types, construction, components (peripherals).
- Process analysis and requirements management for collaborative robot use with integrated stakeholder analysis.
- Methods for conveying technologies to craftsmen.
- Parametric-associative conceptual design of new components and products.
- Automated robot programming and process simulation.
- Design for manufacturing and assembly (DFMA).
- Systematic validation as digital and physical mock-ups in the state-of-the-art digital and robotics lab (Building.Lab).
- Validation of results and verification through iterations.
- Development of initial implementation ideas.
- Team-based collaboration in highly interdisciplinary development teams from various faculties.

Notes:

- The course is suitable for both beginners without programming/robotics knowledge and advanced students with strong programming skills.
- The focus is on the application integration of robotic systems, such as FANUC CRX25iA, DOBOT Magician, various linear-axis robots, and associated subsystems, as well as the development of new peripheral components, end-effectors, processes, and product structures.

Learning objectives: Professional competence

After successfully completing the submodule, students will be able to

- Understand methods, technologies, and systems and grasp technical terms of robotics in a multidisciplinary context (2).
- Understand basic use cases for robotics in various application fields and be able to formulate them accurately (2).
- Be familiar with integrated solutions (from digital models to robot control) for partial tasks/systems (1).
- Strategically plan and implement the (further) development or integration of a technology-based solution into an application case or system context (3).

Learning objectives: Personal competence

After successfully completing the sub-module, students will be able to

- Assess their own knowledge in relation to the subject area and continuously develop it (2).
- Evaluate the opportunities and risks of robotics, also considering non-technical factors (ecological, economic, legal context, ethical, etc.) (2).
- Contribute their skills and approaches in a goal-oriented manner to multidisciplinary teams (3).

Literature
Will be announced during the course.
Further information about the course
Places are limited (10 for MEM)

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Cybercraft Archive: Augmented Reality Crafting	**CYA**

Responsible	Faculty
Prof. Florian Weininger Prof. Christophe Barlieb	Civil Engineering
Lecturer	**Frequency**
Prof. Christophe Barlieb Prof. Florian Weininger	Every semester
Teaching format	
Seminar-based teaching, with project work Seminar, project-based learning	

Semester according to study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1, 2, 3	4 SWS	German/English	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
Portfolio assessment Portfolio review

Contents
Industry 4.0 represents a transformation in our modern societies. Among other things, one area is sometimes overlooked: skilled trades. Yet cooperation between humans and machines is obvious in this area – how can robotics mimic human characteristics in skilled trades, and to what extent can robotics relieve and support humans? In this seminar, we would like to examine the opportunities and challenges of so-called adaptive robotic practices. Using use cases from local craft businesses, we will jointly examine the extent to which adaptive robotics and machine learning can advance the craft. First, the group will select a craft activity that is "typically human" (e.g. drawing or clay modelling). The aim of this seminar is to examine these craft-based, human practices, record them in a database (CyberCraft Archive) and reproduce them using adaptive robotics and machine learning. Interdisciplinary and collaborative work plays a central role here; in this seminar, you will have the opportunity to apply your expertise in the fields of computer science, sensor technology, electrical engineering and/or engineering. Specific content (examples): • Introduction in Adaptive Robotic Practices, Mixed Reality, Motion Tracking, force-torque sensors, parametric modelling, machine learning and robot simulation • Basic concepts of adaptive robotic practices: advantages and disadvantages • How to develop algorithms to streamline adaptive robotic practices? • How do you programme scripts for adaptive robotic practices and mixed reality? • Introduction to and use of different software: in the first few weeks, participants can familiarise themselves with the tools used in the seminar, for example by means of tutorials.
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to • have a broad, practical understanding of cybercrafts: new design, planning and manufacturing processes using motion tracking, parametric design, augmented reality, machine learning and robot simulation. (1) • Students can apply their acquired knowledge using motion tracking, parametric design, augmented reality, machine learning and robot simulation to solve problems in their projects. (2) • Students have strong team-building and transdisciplinary experience and knowledge. (2) • understand the advantages and disadvantages of parametric, generative and algorithmic design systems in the fields of design, construction and manufacturing. (3) • understand the significance of these new cyber practices and can assess their social and economic impact. (3) After completing the module

- students will have a broad, practical understanding of cybercrafts: new design, planning, and manufacturing techniques using motion tracking, parametric design, augmented reality, machine learning, and robotic simulation. (1)
- Students will be able to apply their acquired knowledge using motion tracking, parametric design, augmented reality, machine learning, and robot simulation to solve problems in their projects. (2)
- Students will have strong team-building and transdisciplinary experience and knowledge. (2)
- Understand the advantages and disadvantages of parametric, generative, and algorithmic design systems in the areas of design, engineering, and manufacturing. (3)
- Understand the significance of these new cyber practices and can assess their social and economic impact. (3)

Literature

Further information about the course

Requirements:
Basic knowledge of databases and programming is an advantage

Offered for the following degree programmes:
A (5)
MEM (15)
Open to students from the following faculties: IM, EI, M (5) Total
max. 25 participants

Upon request, the course can be held in English.

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
Digitalisation and Ethics	**DUE**

Responsible	Faculty
Prof. Dr. Thomas Kriza	Applied Natural and Cultural Sciences
Lecturer	Frequency
Prof. Dr. Thomas Kriza	only in the winter semester
Teaching format	
Seminar-based teaching, as a block course	

Semester of study according to the curriculum	Scope of teaching [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	2 SWS	German	2

Time commitment:

Classroom study	Independent study
30	30

Study and examination performance
Portfolio assessment
Permitted aids for performance assessment
All

Contents
The course focuses on the *technical* developments of *digitalisation* and the associated *social changes* and *ethical issues*. In particular, it addresses: • Technical aspects of digitalisation: including artificial intelligence, big data analysis, social media, smart homes, virtual reality, digitalised medicine and biotechnology, etc. • Effects of digitalisation on society, individuals and the world of work: including human relationships and communication in social media, personalised (electoral) advertising, living and working in Industry 4.0, the "transparent" human being/citizen/patient, etc. • Ethical issues of digitalisation: including "What is the importance of privacy and data protection in a digital world?" and "How can we, as free and self-determined individuals with inviolable human dignity, benefit from the technical developments of digitalisation in a spirit of solidarity?" • The defining cultural images of humanity, values and horizons of meaning in the present day, as well as the patterns of thought associated with the dynamics of modern technology The selection of examples and fields of application will be directly related to the participants' field of study. No special technical knowledge is required.

Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to • be familiar with key technical aspects of digitalisation (1) and understand the core of how it works (3). • assess the effects of digitalisation on society and on people's individual and professional lives using specific examples, while keeping in mind both the potential and the risks of technology (2). • understand fundamental cultural values and views of humanity (1) and ethically assess the technical potential of digitalisation against this backdrop (3). • understand key ethical and philosophical questions of digitalisation, taking a reflective ethical stance and justifying it to others (3). • Develop an awareness of ethically responsible behaviour in dealing with the technical possibilities of digitalisation in open discussions with others (3). Acquire knowledge independently and on one's own responsibility from suitable sources, taking into account English-language specialist literature, and use this to prepare for the performance assessment (3).
Literature
Further information on the course
Offered for the following degree programmes: MDB/MBB **MEM** MAPR A total of max. 40 participants

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Cognitive Systems	**KS**

Responsible	Faculty
Prof. Dr. Markus Goldhacker	Mechanical Engineering
Lecturer	Frequency
Prof. Dr. Markus Goldhacker	Winter semester only
Teaching	
Seminar-based teaching	

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	German	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
Written examination (90 minutes), electronic
Permitted aids for performance assessment
All (except applications such as ChatGPT)

Contents
In this seminar, selected areas of *machine learning* – especially *deep* learning *learning* – in technical and non-technical contexts in an application-oriented manner and motivated from a biological/cognitive perspective. In addition to a methodological introduction and practical application through exercises and mini-projects, the theoretical background of various algorithms and models will also be taught. **Specific content:** • Possibilities for transferring cognitive abilities to technical systems • Understanding of properties of systems: e.g. trainability, generalisability, reproducibility • Focus on and in-depth study of specific aspects of machine learning and deep learning • Structure and properties of different types of adaptive systems: variants of artificial neural networks (e.g. CNN, RNN, LSTM, autoencoders, GANs), reinforcement learning, matrix factorisation, etc. • Validation of machine learning models: e.g. signal detection theory as the cognitive basis of a confusion matrix and ROC curves • Understanding algorithms for training adaptive structures: e.g. gradient descent, backpropagation • Improvement of training through artificial augmentation of training data • Understanding typical problems in training and operating cognitive systems: e.g. overfitting, explainability of learned behaviour • Application technically represented cognitive properties in various disciplines • Motivation of various algorithms based on their biological/cognitive foundations The working medium is the programming language *Python* and *JupyterLab/JupyterNotebook*. In *Python*, tutorials can be used to familiarise yourself with the language in the first few weeks of the course, and further Python knowledge will be taught *on the fly* in parallel with the content topics.
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to • Analysing, abstracting and modularising solutions to engineering and non-technical problems through the use of cognitive systems (2) • Generating, labelling and augmenting training and test data (2) • existing training and test data with regard to usability for given training tasks (2) • select, train and test adaptive structures and suitable training algorithms in a task-oriented manner (2) • Evaluate the performance of machine learning models in training and productive operation on the basis of given key figures in a task-specific manner (2) • Implement machine learning and deep learning as a separate layer in existing planning, control and regulation systems (1) • use existing hardware and software tools – especially Python – for design and training (2)

Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to • understand textually and/or graphically specified requirements for cognitive systems and develop solutions that meet these requirements (2) • discuss and work on complex tasks in the field of cognitive systems in a team (2) • weigh up the use of machine learning approaches against the alternative use of classic, non-data-driven methods (1) • present analysis and calculation results in technical discussions (1) • understand the central importance of machine learning for technical and non-technical tasks (1) • understand cognitive systems as an essential element of Industry 4.0 (1)
Teaching materials provided
Slides and exercise sheets in the form of JupyterNotebooks
Teaching media
Overhead projector, blackboard
Literature
Will be announced during the course
Further information about the course
Prerequisites Knowledge of any programming language is required. If you have experience in a programming language other than Python, you can familiarise yourself with Python in the first two weeks using tutorials recommended by the lecturer. Number of participants MEM: 5 people

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Module name (English name if applicable)	Module code or no.
German Culture, Economy and Society	GCES/I 4

Module coordinator	Faculty
Gudrun Seebauer (LB) Prof. Dr Johannes Wild	General Science Programme Applied Natural and Cultural Sciences

Semesters according to the study plan	Study section	Module type	Workload [ECTS credits]
1, 2, 3		Focus Elective module	12

Mandatory requirements
None
Recommended prior knowledge
Depending on the module

Contents
See following pages

Learning objectives: Personal competence
After successfully completing the module, students will be able to See following pages

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Assigned sub-modules:

No	Name of sub-modules	Teaching scope [SWS or UE]	Workload [ECTS credits]
1	English for Master's Students	8 SWS	8
2.	German Economy and Society	2 SWS	2
3	German for International Students: A1	6 SWS	8
4	German for International Students: A2	6 SWS	8
5	German for International Students: B1.1	4 SWS	4
6	German for International Students: B1.2	4 SWS	4
7	German for International Students: B2.1	4 SWS	4
8	German for International Students: B2.2	4 SWS	4
9.	How to Apply in English	2 SWS	2

Information on compulsory courses and options
Enrolment in courses within the *German for Master Students* module can only be done after application and approval by the PK.

Submodule	**TM abbreviation**
English for Master Students	

Responsible	Faculty
Prof. Dr Johannes Wild	Applied Natural and Cultural Sciences
Lecturer	Frequency
Lecturer in the AW programme (LB)	Every semester
Teaching format	
Seminar-based teaching for compulsory elective modules in specific subjects	

Semester of study according to the study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	8 SWS	English	8

Time commitment:

Classroom study	Independent study
120	120

Study and examination requirements
See AW catalogue
Approved aids for performance assessment
See AW catalogue

Contents
See AW catalogue
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to See AW catalogue
Teaching materials offered
See AW catalogue
Teaching media
See AW catalogue
Literature
See AW catalogue
Further information on the course
Students choose from the language courses offered by the AW programme at OTH Regensburg English courses comprising 7 SWS and 7 ECTS. Enrolment in a language course can only take place after application and approval by the PK.

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
German Economy and Society	

Responsible	Faculty
Prof. Dr Johannes Wild Gudrun Seebauer (LB)	Applied Natural and Cultural Sciences
Teacher/Lecturer	**Frequency**
Gudrun Seebauer (LB)	Every semester
Teaching format	
Seminar-based teaching	

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1, 2, 3	2 SWS	English	2

Time commitment:

Classroom study	Independent study
30	30

Coursework and examination
Portfolio assessment portfolio review For details, see study plan
Permitted aids for performance assessment
none

Contents
The five main topics to be covered (in combination with the five main IC principles) are: • Maps of Germany in combination with the definition of culture. • German history from the Reformation to reunification (1980s–90s), discussed from a cultural perspective. • Education and social systems as a reflection of a number of German cultural values. • An outline of the economic and industrial structure of Germany with a focus on Germany's most important sectors. EIL in business communication in Germany will also be looked at • at here. • Immigration and integration, including the intercultural aspects of cultural adjustment.
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to: Students should be enabled: • to understand German history and its implications for the current situation (2). • to use their knowledge to adjust to German cultural standards (3). • to gain a deeper cultural understanding of their experience in Germany (2).

Teaching materials offered
Presentations, maps
Literature
Further information about the course
Short name for WebUntis: AW_INT_GES Module no. 9910730

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM short name**
German for International Students: A1	

Responsible	Faculty
Sheryl Schneider	Applied Natural and Cultural Sciences
Lecturer	Frequency
Lecturer at the Faculty of AM (LB)	Every semester

Teaching format
See module handbook AW (general science elective programme)

Semesters of study according to the study plan	Scope of teaching [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	6 SWS	German	8

Time commitment:

Classroom study	Independent study
120	120

Study and examination requirements
see study plan AW
Approved aids for performance assessment
see study plan AW

Contents
see module handbook AW
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to see module handbook AW
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to see module handbook AW
Teaching materials offered
see module handbook AW
Teaching media
see module handbook AW
Literature
see module handbook AW

Further information on the course
see module handbook AW

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
German for International Students: A2	

Responsible	Faculty
Sheryl Schneider	Applied Natural and Cultural Sciences
Lecturer	Frequency
Lecturer at the Faculty of AM (LB)	Every semester

Teaching format
see module handbook AW (general science elective programme)

Semester according to the study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	6 SWS	German	8

Time commitment:

Classroom study	Independent study
120	120

Study and examination performance
See study plan AW
Approved aids for performance assessment
see study plan AW

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see module handbook AW
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to see module handbook AW
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to see module handbook AW
Teaching materials offered
see module handbook AW
Teaching media
see module handbook AW
Literature
see module handbook AW

Further information on the course
see module handbook AW

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
German for International Students: B1.1	

Responsible	Faculty
Sheryl Schneider	Applied Natural and Cultural Sciences
Lecturer	Frequency
Lecturer at the Faculty of AM (LB)	Every semester

Teaching format
see module handbook AW (general science elective programme)

Semester according to the study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	German	4

Time commitment:

Classroom study	Independent study
60	60

Study and examination requirements
see study plan AW
Approved aids for performance assessment
see study plan AW

Contents
see module handbook AW
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to see module handbook AW
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to see module handbook AW
Teaching materials offered
Interactive course book, additional exercises as handouts or in ELO, videos, additional online material (course and exercise book, additional exercises on handouts or in ELO).
Teaching media
see module handbook AW
Literature
See module handbook AW

Further information on the course
see module handbook AW

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
German for International Students: B1.2	

Responsible	Faculty
Sheryl Schneider	Applied Natural and Cultural Sciences
Lecturer	Frequency
Lecturer at the Faculty of AM (LB)	Every semester
Teaching format	
see module handbook AW (general science elective programme)	

Semester according to the study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1, 2, 3	4 SWS	German	4

Time commitment:

Classroom study	Independent study
60	60

Study and examination requirements
see study plan AW
Approved aids for performance assessment
see study plan AW

Contents
see module handbook AW
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to see module handbook AW
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to see module handbook AW
Teaching materials offered
see module handbook AW
Teaching media
see module handbook AW
Literature
see module handbook AW

Further information on the course
see module handbook AW

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
German for International Students: B2.1	

Responsible	Faculty
Sheryl Schneider	Applied Natural and Cultural Sciences
Lecturer	Frequency
Lecturer at the Faculty of AM (LB)	Every semester

Teaching format
see module handbook AW (general science elective programme)

Semester according to the study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	German	4

Time commitment:

Classroom study	Independent study
60	60

Study and examination performance
See study plan AW
Approved aids for performance assessment
see study plan AW

Contents
see module handbook AW
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to see module handbook AW
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to see module handbook AW
Teaching materials offered
see module handbook AW
Teaching media
see module handbook AW
Literature
see module handbook AW

Further information on the course
see module handbook AW

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
German for International Students: B2.2	

Responsible	Faculty
Sheryl Schneider	Applied Natural and Cultural Sciences
Lecturer	Frequency
Lecturer at the Faculty of AM (LB)	Every semester
Teaching format	
see module handbook AW (general science elective programme)	

Semester according to the study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	German	4

Time commitment:

Classroom study	Independent study
60	60

Study and examination requirements
see study plan AW
Approved aids for performance assessment
see study plan AW

Contents
see module handbook AW
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to see module handbook AW
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to see module handbook AW
Teaching materials offered
see module handbook AW
Teaching media
see module handbook AW
Literature
see module handbook AW

Further information about the course
see module handbook AW

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
How to Apply in English	

Responsible	Faculty
Prof. Dr. Johannes Wild Gudrun Seebauer (LB)	Applied Natural and Cultural Sciences
Lecturer	**Frequency**
Gudrun Seebauer (LB)	Every semester
Teaching format	
Seminar-based teaching	

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	2 hours per week	English	2

Time commitment:

Classroom study	Independent study
30	30

Coursework and examination
Portfolio assessment portfolio review For details, see study plan
Permitted aids for performance assessment
see study plan table see study plan

Contents
This course aims to improve students' applications in English for internships, part-time and full-time positions in Germany, the UK, and the USA, including: positions in Germany, the UK, and the USA, including: • Writing English cover letters for applying in Germany • Writing English cover letters for applying in the UK and the USA • Assessment centre training • Writing compelling CVs • Training for job interviews
Learning objectives: Professional competence
After successfully completing this sub-module, students will be able to: • able to write CVs and cover letters in a convincing manner (3). • confident in job interviews and assessment centres (3). • able to adapt their CV and cover letter to the respective job description (3). • able to apply in different countries (UK, USA, Germany) (3).

Teaching materials offered
• Presentations • Exercises • Individual sessions
Literature
Further information about the course
Short name for WebUntis: AW_INT_HAE Module no. 9910910

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Module name (English name if applicable)	Module code or no.
International Research Methodology and Communication	IRMC/I 2

Module coordinator	Faculty
Gudrun Seebauer (LB) Prof. Dr Johannes Wild	General Science Programme Applied Natural and Cultural Sciences

Semester according to study plan	Study section	Module type	Workload [ECTS credits]
1st, 2nd, 3rd		Focus Elective module	12

Compulsory prerequisites
None
Recommended prior knowledge
Depending on the module

Contents
See following pages

Learning objectives: Personal competence
After successfully completing the module, students will be able to See following pages

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Assigned sub-modules:

No.	Name of sub-modules	Teaching scope [SWS or UE]	Workload [ECTS credits]
1	English for Master's Students	8 SWS	8
2.	German for International Students: A1	6 SWS	8
3	German for International Students: A2	6 SWS	8
4	German for International Students: B1.1	4 SWS	4
5	German for International Students: B1.2	4 SWS	4
6	German for International Students: B2.1	4 hours per week	4
7	German for International Students: B2.2	4 SWS	4
8.	Project Management	2 SWS	2
9	Research Methodology	2 SWS	2

Information on compulsory courses and options
Enrolment in courses within the modules *English for Master Students* and *German for International Students* can only be done after application and approval by the PK.

Submodule	**TM abbreviation**
English for Master Students	

Responsible	Faculty
Prof. Dr Johannes Wild	Applied Natural and Cultural Sciences
Lecturer	Frequency
Lecturer in the AW programme (LB)	Every semester

Teaching format
Seminar-based teaching for compulsory elective modules in specific subjects

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	8 SWS	English	8

Time commitment:

Classroom study	Independent study
120	120

Study and examination requirements
See AW catalogue
Approved aids for performance assessment
See AW catalogue

Contents
See AW catalogue
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to See AW catalogue
Teaching materials offered
See AW catalogue
Teaching media
See AW catalogue
Literature
See AW catalogue
Further information on the course
Students choose from the language courses offered by the AW programme at OTH Regensburg English courses comprising 7 SWS and 7 ECTS. Enrolment in a language course can only take place after application and approval by the PK.

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
German for International Students: A1	

Responsible	Faculty
Sheryl Schneider	Applied Natural and Cultural Sciences
Lecturer	Frequency
Lecturer at the Faculty of AM (LB)	Every semester

Teaching format
see module handbook AW (general science elective programme)

Semester according to the study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	6 SWS	German	8

Time commitment:

Classroom study	Independent study
120	120

Study and examination performance
see study plan AW
Approved aids for performance assessment
see study plan AW

Contents
see module handbook AW
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to see module handbook AW
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to see module handbook AW
Teaching materials offered
see module handbook AW
Teaching media
see module handbook AW
Literature
see module handbook AW

Further information on the course
see module handbook AW

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
German for International Students: A2	

Responsible	Faculty
Sheryl Schneider	Applied Natural and Cultural Sciences
Lecturer	Frequency
Lecturer at the Faculty of AM (LB)	Every semester

Teaching format
see module handbook AW (general science elective programme)

Semester according to the study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	6 SWS	German	8

Time commitment:

Classroom study	Independent study
120	120

Study and examination requirements
see study plan AW
Approved aids for performance assessment
see study plan AW

Contents
see module handbook AW
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to see module handbook AW
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to see module handbook AW
Teaching materials offered
see module handbook AW
Teaching materials
see module handbook AW
Literature
see module handbook AW

Further information on the course
see module handbook AW

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
German for International Students: B1.1	

Responsible	Faculty
Sheryl Schneider	Applied Natural and Cultural Sciences
Lecturer	Frequency
Lecturer at the Faculty of AM (LB)	Every semester

Teaching format
See module handbook AW (general science elective programme)

Semesters of study according to the study plan	Teaching load [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	German	4

Time commitment:

Classroom study	Independent study
60	60

Study and examination requirements
see study plan AW
Approved aids for performance assessment
see study plan AW

Contents
see module handbook AW
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to see module handbook AW
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to see module handbook AW
Teaching materials offered
Interactive course book, additional exercises as handouts or in ELO, videos, additional online material (course and exercise book, additional exercises on handouts or in ELO).
Teaching media
see module handbook AW
Literature
see module handbook AW

Further information on the course
see module handbook AW

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
German for International Students: B1.2	

Responsible	Faculty
Sheryl Schneider	Applied Natural and Cultural Sciences
Lecturer	Frequency
Lecturer at the Faculty of AM (LB)	Every semester

Teaching format
see module handbook AW (general science elective programme)

Semester according to the study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1, 2, 3	4 SWS	German	4

Time commitment:

Classroom study	Independent study
60	60

Study and examination performance
See study plan AW
Approved aids for performance assessment
see study plan AW

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After successfully completing the sub-module, students will be able to see module handbook AW
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to see module handbook AW
Teaching materials offered
see module handbook AW
Teaching media
see module handbook AW
Literature
see module handbook AW

Further information on the course
see module handbook AW

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
German for International Students: B2.1	

Responsible	Faculty
Sheryl Schneider	Applied Natural and Cultural Sciences
Lecturer	Frequency
Lecturer at the Faculty of AM (LB)	Every semester

Teaching format
see module handbook AW (general science elective programme)

Semester according to the study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1, 2, 3	4 SWS	German	4

Time commitment:

Classroom study	Independent study
60	60

Study and examination requirements
see study plan AW
Approved aids for performance assessment
see study plan AW

Contents
see module handbook AW
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to see module handbook AW
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to see module handbook AW
Teaching materials offered
see module handbook AW
Teaching media
see module handbook AW
Literature
see module handbook AW

Further information on the course
see module handbook AW

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
German for International Students: B2.2	

Responsible	Faculty
Sheryl Schneider	Applied Natural and Cultural Sciences
Lecturer	Frequency
Lecturer at the Faculty of AM (LB)	Every semester

Teaching format
see module handbook AW (general science elective programme)

Semester according to the study plan	Scope of teaching [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	German	4

Time commitment:

Classroom study	Independent study
60	60

Study and examination requirements
see study plan AW
Approved aids for performance assessment
see study plan AW

Contents
see module handbook AW
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to see module handbook AW
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to see module handbook AW
Teaching materials offered
see module handbook AW
Teaching media
see module handbook AW
Literature
see module handbook AW

Further information on the course
see module handbook AW

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
Project Management	**PM**

Responsible	Faculty
Prof. Dr Johannes Wild	Applied Natural and Cultural Sciences
Lecturer	Frequency
To be announced	Every semester

Teaching format
Seminar-based teaching for compulsory elective modules in specific subjects

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	2 SWS	English	2

Time commitment:

Classroom study	Independent study
30	30

Coursework and examination
Written examination, 90 min.
Permitted aids for assessment
see study plan table

Contents

- The lessons given will introduce you to the methodology and tools for successfully manage technical projects with a strong emphasis on technical project management.
- Classic, agile and hybrid methodologies are discussed and compared.
- The typical structure of projects is introduced with an additional focus on the special demands for managing and working in interdisciplinary projects according to the typical product development process used in the automotive industry. An outlook on functional safety-compliant product development is provided.
- Necessary tools and methods for managing schedules, costs, quality, risks, stakeholders, procurement, communication, quality, changes, and conflicts in a project are introduced.

Learning objectives: Professional competence

After successfully completing the sub-module, students will be able to

- The goal is to gain a good understanding of the structure of projects and procedure models for classic, agile and hybrid managed projects (1).
- The ability to work with project management tools (2) as a member of a project team, such as participating in project planning, time and resource scheduling, and risk assessments (2).
- Gain sufficient knowledge about management to be able to lead smaller, less complex projects (3).

- Being able to choose the correct approach for conducting a project, including classic, agile and hybrid procedural models (2).
- Gaining an overview (1) of the field of project management to extend knowledge (2) about how to plan and control a project in self-studies with specialised literature

Learning objectives: Personal competence

After successfully completing the sub-module, students will be able to

- Understand the interaction between stakeholders in a project and management of conflicts in complex working environments (1).
- Understand leadership culture in projects and integration of project teams in a corporate culture (1).
- Be able to work in an interdisciplinary and cross-departmental project team by understanding stakeholder goals and interactions (2).

Teaching materials provided

PowerPoint slides, literature suggestions, toolbox (templates) for leading a project

Teaching media

Slides, (virtual) whiteboard

Literature

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Research Methodology	

Responsible	Faculty
Prof. Dr Johannes Wild Gudrun Seebauer (LB)	Applied Natural and Cultural Sciences
Lecturer	**Frequency**
Gudrun Seebauer (LB)	Every semester
Teaching	
Seminar-based teaching for compulsory elective modules in specific subjects	

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	2 SWS	English	2

Time commitment:

Classroom study	Independent study
30	30

Study and examination performance
Portfolio review/portfolio assessment for details see study plan
Approved aids for performance assessment
See AW catalogue

Contents
See AW catalogue
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to See AW catalogue
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to See AW catalogue/see AW-catalogue
Teaching materials offered
See AW catalogue
Teaching media
See AW catalogue

Literature
See AW catalogue
Further information on the course
Further details can be found in the course catalogue of the AW programme at OTH Regensburg.

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Module name (English name if applicable)	Module code or no.
Consolidation	V

Module coordinator	Faculty
Prof. Dr Mikhail Chamonine Prof. Dr. Thomas Fuhrmann Prof. Dr. Rainer Holmer Prof. Dr. Corinna Kaulen Prof. Dr. Hans Meier Prof. Dr. Michael Niemetz Klaus Pressel (LB) Prof. Dr. Rupert Schreiner Prof. Dr. Martin Schubert Prof. Dr. Thomas Stücke Prof. Dr. Heiko Unold Richard Weininger (LB) Prof. Dr. Vooi Voon Yap	Electrical Engineering and Information Technology Electrical Engineering and Information Technology Electrical Engineering and Information Technology Applied Natural Sciences and Cultural Studies Electrical Engineering and Information Technology Electrical Engineering and Information Technology Applied Natural and Cultural Sciences Applied Natural and Cultural Sciences Electrical Engineering and Information Technology Electrical Engineering and Information Technology Electrical Engineering and Information Technology Electrical Engineering and Information Technology Applied Natural and Cultural Sciences

Semesters of study according to the study plan	Study section	Module type	Workload [ECTS credits]
1, 2, 3		Focus Elective module	5

Compulsory prerequisites
Depending on module
Recommended prior knowledge
Depending on the module

Contents
See following pages

Learning objectives: Personal competence
After successfully completing the module, students will be able to See following pages

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Assigned sub-modules:

No	Name of sub-modules	Scope of teaching [SWS or UE]	Workload [ECTS credits]
1.	Advanced Methods of Quality Management	4 SWS	5
2.	Advanced Optical Sensing	4 SWS	5
3	Advanced Packaging (dual)	4 SWS	5
4	Advanced Semiconductor Technology (dual)	4 SWS	5
5	Electronic Product Engineering	4 SWS	5
6	Electromagnetic Compatibility (Electromagnetic Compatibility)	4 SWS	5
7	Embedded Linux	4 SWS	5
8	Fibre optic communication	4 SWS	5
9	RF Circuit Design Design)	4 SWS	5
10.	Intelligent Material Systems and Metamaterials	4 SWS	5
11	LabVIEW projects	4 SWS	5
12	LED Technology (dual)	4 SWS	5
13	Multi-processor and multi-core design for reliable embedded systems	4 SWS	5
14	Overview of semiconductor fabrication in a high-volume environment	4 SWS	5
15	Physics of Semiconductor Devices (Physics of Semiconductor Devices)	4 SWS	5
16	Quantum Theory and Information	4 SWS	5
17	Surface Engineering of Semiconductor Materials	4 SWS	5
18	Theoretical Electrical Engineering (Theoretical Electrical Engineering)	4 SWS	5
19	Advanced Microcontroller Techniques for Master's Degree (Advanced Microcontroller Techniques for Master's Degree)	4 SWS	5

Information on compulsory courses and options
Requirements for dual students: Dual students must take **at least two modules** from the elective module catalogue for specialisations, **totalling 10 credits**, which are offered by lecturers from the practice partners for dual students at OTH Regensburg. These modules are specially marked in the module catalogue. If places are still available, these modules are also open to non-dual students.

Submodule	TM abbreviation
Advanced Methods of Quality Management	**AQM**

Responsible	Faculty
Prof. Dr Johannes Wild	Applied Natural and Cultural Sciences
Lecturer	Frequency
Dr Martin Winkler (LB)	Winter semester only

Teaching
Seminar-based teaching for compulsory elective modules in specific subjects

Semester according to study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	English	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
See elective module catalogue for *Master's in Electrical and Microsystems Engineering*
Approved aids for performance assessment
See curriculum table

Contents

- QM - basics and terms (repetition and common basis for mutual communication)
- Basics of management and quality management models; process concept, leadership, environment and context, stakeholders, requirements management, process map, organisational structure and processes, etc.
- Quality management in different industries
- Total Quality Management (TQM) with relevant models for implementation (e.g. EFQM)
- Management systems in various forms, similarities and differences (e.g. PRINCE2, CMMI, ISO 9001, etc.)
- Current developments in the area of QM and management systems
- Communication and information in teams and organisations, basics, models, methods
- Methods for generating ideas in teams
- Methods and tools (e.g. 8D, Six Sigma, Poka Yoke, risk management/FMEA, audits, CIP, problem-solving methodology/Ishikawa/5why, etc.)

Learning objectives: Professional competence

After successfully completing the sub-module, students are able to:

- Building on basic knowledge of quality and process management as well as operational organisation, students can apply their knowledge in the field of management

systems, in particular quality management systems (QM systems) and relevant quality management methods in a targeted manner and in line with the current state of science (3).
- They are thus able to improve management systems in the organisation and develop them further to excellence in close cooperation with all operational functional areas (3).
- This applies in particular to the inclusion of non-technical aspects in the subject area of this course (2).
- The students can specifically characterise a company's QM system, analyse its interaction with other management approaches and initiate a sustainable improvement of the entire management system through effective and efficient use of methods. This applies in particular to the interaction of technical and non-technical functional areas of a company (2).
- The students are also able to apply scientific methods and write scientific papers in the taught areas (2)

Learning objectives: Personal competence

After successfully completing the sub-module, students are able to:
- The students can cooperate in a team in a goal-oriented manner (teamwork skills) and communicate appropriately (2).
- They are able to develop work results in a way that is appropriate for the target group, present them and defend them professionally (presentation, argumentation, giving and receiving feedback) (3)
- The students are aware of the role of modern quality management in the organisation, in particular the fact that QM and other approaches complement each other and that participation in quality management is not limited to belonging to a corresponding organisational unit (3).

Teaching materials offered

Script (ELO)

Teaching media

Board, notebook, projector

Literature

Required reading:

- Script (ELO) regarding Advanced Methods of Quality Management

Additional reading:

- Crosby, Ph. B., Quality Is Free, New York, 1979
- Crosby, Ph. B., Quality Without Tears, New York, 1984
- Hammer, Michael, The Process-Centred Company, Campus Verlag, 1997
- Kamiske, G. F., Brauer, J.-P., Quality Management from A to Z, Carl Hanser Verlag 2011
- Masing, W., Handbook of Quality Management, Hanser, 2014
- Müller, E., Quality Management for entrepreneurs and managers, Springer Gabler 2014
- Schmelzer, H., Sesselmann, W., Business Process Management in practice Zollondz, H.-D., Grundlagen Qualitätsmanagement (Fundamentals of Quality Management), Oldenbourg, 2011
- Zollondz, H.-D., Fundamentals of Quality Management, Oldenbourg, 2011
- Zollondz, H.-D., Fundamentals of Lean Management, Oldenbourg, 2013
- Brüggemann, Holger – Fundamentals of Quality Management (2020)
- Drews, Günter; Hillebrand, Norbert – Encyclopaedia of Project Management Methods (2007)
- Nöllke, Matthias – Creativity Techniques (2015)
- Scherer, Jiri; Brügger, Chris – Creativity Techniques (2012)
- Quality Management; QM systems, procedures and terminology; DIN e.V. (2021)
- Goetsch, Davis – Quality Management for Organisational Excellence: Introduction to Total Quality; Pearson New International Edition (2013)
- Oakland, Morris – TQM: A Pictorial Guide for Managers; Routledge (2016)
- Gerhard and Elske Linß, Quality Management – Methods and Tools: Planning, Implementation, Evaluation and Improvement, Hanser (2024)
- Linß et al.; Quality Management – Integrated Management Systems: Environment, Energy, Occupational Safety and Information Security, Hanser (2024)
- Nancy R. Tague; The Quality Toolbox, Third Edition; American Society For Quality; (2024)

Websites:

- ISO: www.iso.org; ISO 9001:2015: www.iso.org/standard/62085.html
- IATF: www.iatfglobaloversight.org/
- IATF 16949 sanctioned interpretations:
- VDA QMC: vda-qmc.de/
- EFQM: efqm.org
- German Society for Quality: www.dgq.de

Further information about the course

Number of participants: max. 20 students per semester Number of participants: max. 20 students per semester

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
Advanced Optical Sensing	**AOS**

Responsible	Faculty
Prof. Dr Johannes Wild	Applied Natural and Cultural Sciences
Teacher/lecturer	Frequency
Prof. Dr Johannes Wild	Winter semester only

Teaching
Seminar-based teaching for compulsory elective modules in specialist subjects Lecture and seminar

Semester according to study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	English	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
See elective module catalogue for *Master's in Electrical and Microsystems Engineering*
Approved aids for performance assessment
Scientific calculator

Contents

- Light Basics (wavelength, transmission, polarisation, reflection, refraction, interference, diffraction)
- Radiometry and photometry
- Emission of Light (Sun, Incandescent lamp, LED, EEL, VCSEL, OLED/LCD Display)
- Detection of Light (Photodiodes)
- Noise, signal-to-noise ratio, dynamic range
- Sensor circuit concepts
- Package concepts
- Colourimetry
- Ambient light sensing
- Flicker sensing
- Proximity sensing
- Heart rate sensing

Learning objectives: Professional competence

After successfully completing this sub-module, students will be able to

- The students have a fundamental understanding of optical spectra from different light sources and how to measure them with different detector concepts. They know why

different sensors (e.g. ambient light, flicker) are necessary in various electronic devices (e.g. mobile phones). They understand the design, fabrication and system concepts of these sensors. (2)
- Based on their knowledge, they are able to read scientific publications in this field and understand new optical sensor concepts. (2)
- The students are able to support the design process of new sensors and select the suitable components (3)
- They have the capability to work in this field as well as to perform research and development. (3)

Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to • The students are able to explain and present complex concepts (3) • Students become accustomed to working in teams with other students (3) • They are able to familiarise themselves with difficult topics on their own (2)
Teaching materials provided
Collection of lecture slides and exercise questions
Teaching media
Projector, blackboard, notebook
Literature
• Fundamentals of Photonics – Saleh & Teich, Wiley 2007 • Photonics – Rainer Dohlus, Oldenburg 2010 • Zinth & Zinth – Light Rays, Waves and Photons, De Gruyter, 2018 • CMOS Circuit Design, Layout, and Simulation, R. Jacob Baker, Wiley 2019 • Semiconductor Devices – Sze & Lee, Wiley 2007
Further information about the course
Recommended prior knowledge: knowledge of optics, semiconductor physics

The numbers in brackets indicate the levels to be achieved: 1 – know, 2 – can, 3 – understand and apply

Submodule	**TM abbreviation**
Advanced Packaging (dual)	**AP**

Responsible	Faculty
Prof. Dr Johannes Wild	Applied Natural and Cultural Sciences
Teacher/lecturer	**Frequency**
Michael Fügl (LB) Horst Theuss (LB)	Summer semester only
Teaching format	
Seminar-based teaching with exercises	

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1, 2, 3	4 SWS	English	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
See the elective module catalogue for the Master's programme in *Electrical and Microsystems Engineering*
Approved aids for performance assessment
See study plan table

Contents

- Overview: Advanced packaging for mobile communications? A key element of physics to innovation. Modern communication technology systems and markets (introduction to GSM, overview of GPRS, DECT, Bluetooth, etc.)
- Basic structure of a mobile phone (housing considerations): transceiver and baseband section, different transceiver architectures
- Semiconductor technology: The basis for mobile communication circuits, importance of Si technology, CMOS compared to bipolar, III/V semiconductors
- Basic RF circuits for mobile communications: system integration, LNA, mixer, VCO & PLL, filters (SAW, BAW), passive components (R, L, C)
- Importance of packaging technology for mobile communications: system in package, miniaturisation, typical FE & BE packages (BGA, VQFN)
- Technological processes in housing development: wire bonding, die attach, wafer thinning, wafer level packaging, etc.
- Fundamental aspects of flip chip technology
- Ball grid array packages
- Leadless packages, e.g. VQFN
- Challenges at high frequencies
- Reliability and testing of packages
- Outlook

Learning objectives: Technical expertise
After successfully completing this sub-module, students will be able to **Learning objectives**: • Insight into all technical aspects of mobile communications • In particular, detailed knowledge of modern methods of electronic packaging in this context • Knowledge of the interaction between physical constraints and the possibilities of the front end and back end
Teaching materials provided
Current literature provided by the lecturer
Teaching media
Blackboard, notebook, projector
Literature
• Harper, Electronic Packaging and Interconnection Handbook, McGraw-Hill, New York 2005 • Gray et al., Analysis and Design of Analog Integrated Circuits, Wiley, New York 2001,

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
Advanced Semiconductor Technology (dual)	**AST**

Responsible	Faculty
Prof. Dr. Corinna Kaulen	Applied Natural and Cultural Sciences
Lecturer	Frequency
Various lecturers from industry and academia	each semester

Teaching format
Seminar-based teaching for compulsory elective modules in specific subjects

Semesters of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	English	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
See elective module catalogue for Master's in *Electrical and Microsystems Engineering*
Approved aids for performance assessment
See study plan table

Contents
• Semiconductor Materials • Semiconductor Fabrication Technology • Semiconductor Epitaxy • Semiconductor Packaging • Semiconductor Characterisation • Nano-Fabrication: Top-Down (e-beam lithography) and Bottom-Up (self-assembly) Techniques • Si-based modern electronic devices: processing, device physics and applications • Carbon-based nanoelectronic devices: materials (CNT, graphene), fabrication, device physics and potential applications • New Developments in 2D Crystal-Based Heterostructures for Nanoelectronics • New Developments in Nanoelectronic Devices • Novel techniques in photonics and analytics • Semiconductor-based Sensors • Special topics on the large-scale fabrication technology of semiconductors

Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to • The students shall learn to know the fundamentals, the design, the technology and the operation of semiconductor materials and modern semiconductor-based devices (1). • Based on this knowledge, they should be able to read scientific publications in this field and understand the design, fabrication process and operation of semiconductor devices (2). • The students should be able to design/plan the fabrication process for parts of semiconductor components and structures by themselves (3). • The students should be able to select and choose suitable components/materials for specific engineering applications (3).
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to They should be able to join in and work together with an interdisciplinary team of physicists, chemists and engineers for the fabrication of modern semiconductor devices (3).
Teaching materials provided
Course notes, exercises, copies of slides
Teaching media
Board, notebook, projector
Literature
• S.M. Sze, K.K. Ng "Physics of Semiconductor Devices (3rd Ed.): Wiley, 2007 • D. Meschede "Gerthsen Physics", Springer, 2015 • "Fundamentals of Microfabrication and Nanotechnology", Third Edition, Marc J. Madou, by CRC Press (1 August 2011); ISBN: 9780849331800. • “Advanced Nanoelectronics”, Razali Ismail, Mohammad Taghi Ahmadi, Sohail Anwar, by CRC Press (17 December 2012), ISBN: 9781439856802. • “2D Materials for Nanoelectronics”, Michel Houssa, Athanasios Dimoulas, Alessandro Molle, by CRC Press (5 April 2016); ISBN: 9781498704175.
Further information about the course
• Previous Experience/Premise: Knowledge of College Physics, fundamental knowledge of Solid State Physics. In order to attend the module Advanced Semiconductor Technology: • Choose any 2 sub-modules from the list on the MEM Information Board • Admission requirement for registration for the module examination is successful participation (passed) in two sub-modules.• Only one grade is awarded for the entire module.

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Electronic Product Engineering	**EPE**

Responsible	Faculty
Prof. Dr. Rainer Holmer	Electrical Engineering and Information Technology
Lecturer	Frequency
Prof. Dr. Rainer Holmer	Summer semester only

Teaching
Seminar-based teaching for compulsory elective modules in specific subjects

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	English	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
See elective module catalogue for the Master's programme in *Electrical and Microsystems Engineering*
Approved aids for performance assessment
See study plan table

Contents

- Fundamental aspects of the semiconductor industry (technology, product design, front-end/back-end production, testing, quality, logistics)
- Key performance indicators in the semiconductor industry
- Product development: analogue/digital circuitry, physical layout, reuse, use of libraries/macros, design for manufacturability (DfM)
- Test development: test concept, test time and test costs, design for testability (DfT), built-in self-test (BIST)
- From development (prototype) to high-volume production – the start of production and -ramp-up
- Methods for optimising (with regard to key performance indicators) product, technology, production High-volume production: production yield, process stability; dealing with deviations, malfunctions; dealing with changes, updates – change management; traceability

Learning objectives: Professional competence

After successfully completing the sub-module, students will be able to

- interpret fundamental relationships between semiconductor product design, semiconductor production processes and semiconductor testing, their stability and variations and deviations (3)

- Important key performance indicators in the semiconductor industry, such as "time to market", interpret costs, production yield and quality (3)
- Describe specific requirements of semiconductor production and relevant methods and procedures (1)
- Apply methods for analysing production data (parameters, electrical test results, etc.) and statistical process control (2).
- Apply methods for optimising product design, process technology and testing in a targeted manner (2).
- Correctly assess problems and the resulting optimisation potential in the semiconductor industry (3) and make decisions based on this (3).
- Deal with unexpected changes and problems appropriately and competently (3).

Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to See preamble
Teaching materials offered
Lecture notes
Teaching media
Blackboard, notebook, projector
Literature

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Electromagnetic compatibility	**EMC**

Responsible	Faculty
Prof. Dr. Thomas Stücke	Electrical Engineering and Information Technology
Lecturer	**Frequency**
Thomas Eichstetter (LB) Prof. Dr. Thomas Stücke	Summer semester only

Teaching
Seminar-based teaching with exercises and practical work in the EMC laboratory

Semester according to the study plan	Scope of teaching [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	German	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
See elective module catalogue for Master's in *Electrical and Microsystems Engineering*
Approved aids for performance assessment
See study plan table

Contents

Part 1: Theory

- Introduction, terminology, problem description
- Description of interference in analogue and digital systems
- Classification and spectral representation of interference sources in the EMC environment
- Interference paths: Types of coupling, couplings between wires and field couplings in conductor structures

Part 2: Practical application

- Introduction
- Fundamentals of applied EMC: Pulses and transients, electrostatic discharges, electromagnetic waves
- Filtering, shielding, grounding: models, interference signals in the time domain and frequency domain, conducted and radiated interference energies
- Interference suppression measures: passive and active interference suppression, RF components in reality, calculating on a logarithmic scale
- Measurement and testing: EMC measuring instruments, FFT measurement technology, interference emission and immunity, special features of e-mobility, influences of the measurement environment, EMC simulation, tools in development (pre-compliance)
- Practical training in measurement technology: typical test setups for EMC measurements
- EMC development and planning: circuit diagram and layout creation with examples
- EMC documentation

Learning objectives: Professional competence

After successfully completing the sub-module, students will be able to

- describe the basic principles of EMC, explain the different types of coupling, distinguish between internal and external EMC, and classify the causes of electromagnetic incompatibility (2)
- Classify sources of interference according to their characteristics, represent typical interference signals in the time and frequency domains, and perform conversions between the two forms of representation using an EMC table and nomogram (3)
- Determine the characteristic parameters of simple conductor structures, including suitable approximations, with a view to calculating the coupling of short and long lines (3)
- Determine the characteristic parameters of simple antenna structures, including suitable approximations, with a view to calculating the field coupling in short lines (3)
- Calculate interference voltages caused by couplings between lines and field couplings in conductor structures analytically and using approximations (3)
- Select the appropriate filter topology depending on the impedance level and correctly implement shielding and grounding (3)
- Explain the structure of a measuring receiver, including the FFT measurement method, distinguish between narrowband and broadband interference, and describe the differences between the measuring detectors (2)
- Explain the typical measurement setups for conducted and field-bound interference emission measurement using the automotive sector as an example (2)
- EMC guidelines

Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to See preamble
Teaching materials provided
Presentation slides, lecture notes, exercises, reading list
Teaching media
Computer, projector, blackboard, experimental setup in the EMC laboratory
Literature
• Durcansky, G., "EMC-compliant device design", Franzis-Verlag • Gonschorek, K.H., Singer, H., Anke, D. et al., "Electromagnetic Compatibility – Fundamentals, Analyses, Measures", Teubner-Verlag • Schwab, A., "Electromagnetic Compatibility", Springer-Verlag
Further information about the course

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Embedded Linux	**ELX**

Responsible	Faculty
Prof. Dr. Michael Niemetz	Electrical Engineering and Information Technology
Lecturer	Frequency
Prof. Dr. Michael Niemetz	Winter semester only

Teaching
Seminar-based teaching for compulsory elective modules in specific subjects (at computer workstations)

Semester according to the study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	German	5

Time commitment:

Classroom study	Independent study
Lecture: 30 hours; teaching at computer workstations: 30 hours	Preparation and follow-up work: 52 hours; independent study: 38 hours

Study and examination performance
See elective module catalogue for Master's in *Electrical and Microsystems Engineering*
Permitted aids for performance assessment
See study plan table

Contents

Setting up a Linux system
Basic steps in system administration such as installation, user administration, network setup and rights management are taught.

Command line / programme development
The use of the command line is demonstrated using several applications as examples.
The development and compilation of C programmes using common tools (gcc, make, editors) is practised. Simple shell programmes are created. Version control software is also used for this purpose.

File systems
The most important features of the most common file systems are discussed and their setup and integration into the system is practised.

Boot process
The various stages of the boot process up to the running multi-user system are discussed, and the practical setup of a bootable system is carried out.

Embedded Linux
The special requirements of many embedded systems (e.g. storage systems with limited rewritability, real-time capability, limited system memory) are explained and solutions are presented.
limited rewritability, real-time capability, limited system memory) are explained and solutions are presented.

Hardware access and interprocess communication
The main task of embedded applications is to control peripherals.
Modern embedded Linux systems are equipped with a variety of interfaces (e.g. UART, SPI, I2C, GPIO, ADC) for this purpose. The interfaces and the Linux kernel philosophy are explained, and access via C and shell programmes using existing kernel drivers is tested in practice using examples. Fundamental elements of interprocess communication (in particular signals, pipelines, shared memory) are presented and their different properties are discussed.

Interprocess communication
Basic elements of interprocess communication (especially signals, pipelines, shared memory) are presented and their different properties are discussed.

Kernel
Basic structure of a Linux system, user and kernel space, modularisation, kernel parameters, configuration of the kernel

Learning objectives: Professional competence

After successfully completing the submodule, students will be able to use embedded Linux systems in their development work and perform basic system administration tasks.

Participants in the course will acquire the following knowledge (1) (5%): Knowledge of relevant English technical terms

- Basic understanding of Linux philosophy (modular kernel, process model, file systems, multi-user system, rights, network)
- Knowledge of the most important command line tools, editors and system components.
- Knowledge of the most important methods of interprocess communication.
- Knowledge of system architecture, division into kernel and user space, modularisation of the kernel

Course participants will acquire the following skills (2) (55%): Mastering basic administration tasks in

Linux/Unix environments.

- Working with common administration and development tools
- Setting up a Linux operating system on a compatible hardware platform
- Access to embedded-specific controller peripherals (e.g. AD converters, serial bus systems, I/O lines) via existing kernel drivers.
- Kernel configuration and basic procedures for developing own kernel drivers

Participants in the course will acquire the following skills (3) (40%):

- Evaluating the advantages and disadvantages of using Linux in embedded control solutions and making appropriate system design decisions, taking into account the diverse requirements and consequences.
- Presentation and justification of own design decisions
- Developing solutions to problems through teamwork
- Solving complex problems by researching literature and studying hardware and software specifications

Learning objectives: Personal competence

After successfully completing the sub-module, students will be able to develop strategies in highly complex and only partially understood situations
to arrive at solutions to problems through research and by combining this with the technical skills they have acquired.

Further personal skills are not explicitly taught in this course, but are interwoven with the technical skills and tested as far as possible.

Teaching materials offered

- Lecture notes
- Bibliography
- Internship instructions
- Supplementary materials in the corresponding e-learning course

Teaching media

- Blackboard
- Virtual machine with Linux environment (VirtualBox)
- Projector
- Individual personal experimentation equipment (laboratory case) with embedded Linux system
- Electronic components and other accessories

Literature

- Karim Yaghmour, Jon Masters, Gilad Ben-Yossef, Philippe Gerum, Building Embedded Linux Systems, O'Reilly, 2008
- Gene Sally, Pro Linux Embedded Systems, Apress, 2010.
- Christopher Hallinan, Embedded Linux Primer, 2nd Edition, Prentice Hall, 2011
- Michael Kerrisk, The Linux Programming Interface. William Pollock, 2010.
- Christine Wolfinger, Linux-Unix Quick Reference. For users, developers and system administrators. It Compact. Dordrecht: Springer, 2013.
- Chris Simmonds, Mastering Embedded Linux Programming: Packt Publishing, 2nd edition, 2017.
- John Madieu, Linux Device Drivers Development: Develop customised drivers for embedded Linux: Packt Publishing, 2017.

Further information about the course

Successful participation requires sound practical programming skills and
knowledge of a higher programming language (preferably C), a basic understanding of microcontrollers and their peripherals, and experience in the practical use of serial communication buses (SPI and I2C).
Basic knowledge of practical software engineering, such as version management and software design, is helpful.

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
Fibre optic communication	**FOC**

Responsible	Faculty
Prof. Dr. Thomas Fuhrmann	Electrical Engineering and Information Technology
Lecturer	Frequency
Prof. Dr. Thomas Fuhrmann	Winter semester only

Teaching
Seminaristic lecture with practical experiments

Semester of study according to the curriculum	Scope of teaching [SWS or UE]	Language of instruction	Workload [ECTS credits]
1, 2, 3	4 SWS	English	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
See the elective module catalogue for the Master's programme in *Electrical and Microsystems Engineering*
Approved aids for performance assessment
See study plan table

Contents

- Basics of optical fibres: single-mode fibres, multimode fibres, special fibres, polymer Optic Fibres, Photonic Crystal Fibres, Modes, Attenuation, Dispersion, Polarisation Mode Dispersion, Manufacturing Technologies
- Principles of fibre optic communication systems: DWDM systems, CWDM systems, PON systems
- Components for Fibre Optic Communication Systems: Connectors, Lasers, Photodiodes, Modulators, Amplifiers, Attenuators, Filters, Switches, Add-Drop Multiplexers, Dispersion Compensators
- Principles and Components of Integrated Optics
- Modulation formats, bit error detection and forward error correction
- Electronic circuits for lasers and photodiodes
- Fibre Optics Measurement Technology: Optical Power Meter, OTDR, OSA, Wavelength Meter

Learning objectives: Professional competence

After successfully completing this sub-module, students will be able to

- Knowing principles of fibre optic communication systems (2);
- Knowing types of fibres, their properties and usage (1);

- Knowing important components and their functions in fibre optic communication systems (1);
- Knowing principles and basic components in integrated optics (1);
- Knowing modulation formats and bit error handling (1);
- Knowing electronic circuits for lasers and photodiodes (1);
- Knowing principles and devices for fibre optic measurement (1);
- Calculation of important parameters of fibre optic communication systems. (2)
- Analysis of fibre optic communication systems. (3)
- Design of simple fibre optic communication systems according to required applications. (3)

Learning objectives: Personal competence

After successfully completing the sub-module, students will be able to

- Reading and understanding technical texts about fibre optic communication written in English. (3)
- Analysis of technical problems in the field of fibre optic technologies. (3)
- Discussion with colleagues about technical aspects of fibre optic technologies and communication systems. (3)

Teaching materials provided

Script, articles, practical exercises

Teaching media

Blackboard, projector

Literature

Further information about the course

Note: Only for Master's students
Recommended prior knowledge: Maxwell's equations and electromagnetic waves

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
HF circuit design (RF circuit design)	**HFS**

Responsible	Faculty
Prof. Dr. Thomas Stücke	Electrical Engineering and Information Technology
Lecturer	Frequency
Prof. Dr. Thomas Stücke	Winter semester only
Teaching	
Seminar-based teaching with exercises	

Semester according to study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1, 2, 3	4 SWS	German	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
See elective module catalogue for Master's in *Electrical and Microsystems Engineering*
Approved aids for performance assessment
See study plan table

Contents
• Introduction • Radio technology • High-frequency systems • Special features of high-frequency circuits • Waves on lines • Reflection and matching • Scattering parameters • Impedance transformation • Lossless matching networks • Matching with lines • Technologies for planar high-frequency circuits • Passive components at high frequencies • Diodes and bipolar transistors • MOS and junction field-effect transistors • Design methodology for amplifiers • Amplifier stages with partial matching • Amplifier stages with unilateral transistor • Amplifier stages with ideal matching • Stabilisation of amplifier stages • Broadband amplifiers • Low-noise amplifiers • Power amplifiers • Oscillators • Electronically tunable oscillators • Diode mixers • Mixers with transistors • Electronic switches • Current circuit examples
Learning objectives: Technical expertise
After successfully completing the sub-module, students will be able to • explain the special features of electronic circuits in the high-frequency range (2) • use SPICE for computer-aided circuit design (3) • explain the functioning and structure of basic high-frequency circuits (amplifiers, mixers, oscillators) (2) • explain and calculate wave propagation on lines and simulate it with SPICE (3) • interpret the modelling of passive and active components at high frequencies (2) • make the optimal selection of components, technologies and manufacturing processes (3) • Analyse and design high-frequency circuits (3)
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to See preamble

Teaching materials provided
Slide sets for all lessons, circuit files (Spice) for simulation examples
Teaching media
Blackboard/whiteboard, PC/projector, Spice simulation programme
Literature
• U. Tietze, C. Schenk, E. Gamm: Semiconductor Circuit Technology. 14th edition, Springer, 2012 • F. Strauß: Basic Course in High Frequency Technology. 1st edition, Vieweg + Teubner, 2012 • F. Ellinger: Radio Frequency Integrated Circuits and Technologies. 2nd edition, Springer, 2008 • T. H. Lee: The Design of CMOS Radio-Frequency Integrated Circuits. 2nd edition, Cambridge, 2004
Further information about the course
Recommended prior knowledge/prerequisites • Structure and function of diodes, bipolar and field-effect transistors • Large and small signal analysis of electronic circuits • Basic circuits of analogue circuit technology • Using the Spice simulation programme

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
Intelligent Material Systems and Metamaterials	**IMS**

Responsible	Faculty
Prof. Dr. Mikhail Chamonine	Electrical Engineering and Information Technology
Lecturer	Frequency
Prof. Dr. Mikhail Chamonine	Summer semester only

Teaching
Seminar-based teaching with approx. 15% exercises, presentations by students, simulation at computer workstations. Seminar-based teaching with approx. 15% exercises, presentations by students, simulation at computer workstations.

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	English	5

Time commitment:

Classroom study	Independent study
56	62 hours (preparation and follow-up), 32 hours (exam preparation)

Study and examination requirements
see study plan table
Permitted aids for assessment
see study plan table

Contents

Introduction

- Definition of smart materials.
- Overview of different classes of smart materials.

The course will cover some current topics from the following catalogue:

Piezoelectric materials

- Piezoelectric effect
- Piezoelectric ceramics
- Piezoelectric polymers
- Constitutive modelling
- Applications
- Vibration energy conversion (energy harvesting)

Piezoresistive materials as intelligent sensors

- Piezoresistive effect
- Constitutive modelling
- Applications

Electrostrictive materials

- Electrostrictive effect
- Constitutive equations
- Applications

Giant magnetoresistance effect (GMR)

- Physical effect
- Spintronics
- Applications of

Magnetostrictive materials

- Physical effects
- Constitutive equations
- Applications of

Shape memory materials

- Shape memory alloys
- Magnetic shape memory alloys Shape memory polymers
- Electrically conductive polymers as intelligent materials
- Applications

Magnetic gels (ferrogels)

- Magnetoviscoelastic properties
- Constitutive equations
- Magnetic applications

Magnetorheological fluids and elastomers

- Magnetorheological effect
- Physical models
- Applications

Electrorheological fluids

- Electrorheological effect
- Physical models
- Applications

Dielectric elastomers

- Constitutive equations
- Applications

Metamaterials

- Electromagnetic and optical metamaterials
- Elastic metamaterials
- Acoustic metamaterials
- Applications

Smart materials for controlled drug release

- Physical principles
- Applications of

Liquid crystal elastomers

- Introduction
- Modelling and constitutive equations
- Applications

Self-healing materials

Janus particles as intelligent materials

- History and fabrication methods
- Self-assembly structures
- Behaviour in external fields

Learning objectives: Professional competence

After successfully completing this submodule, students will be able to

- Know the most important types of intelligent materials and their areas of application (1)
- Explain physical and chemical phenomena in intelligent materials using the constitutive equations and describe them mathematically (2).
- Be able to draw qualitative conclusions from a small number of physical concepts and laws (2)

- Be able to read and understand the current technical literature on the subject of “intelligent material structures and metamaterials" (2).
- Understand the concept of "intelligent materials and intelligent structures" (3).
- Understand the differences between different physical models for an intelligent material (3).
- Develop design concepts for applications of metamaterials (3).

Learning objectives: Personal competence

After successfully completing the sub-module, students will be able to

- Analyse their own learning progress and learning needs (3) and, if necessary, derive courses of action from this (3),
- Work together with others in a goal-oriented manner (2),
- Understand the interests and social situation of collaborators (2),
- Deal with and communicate with collaborators rationally and responsibly (2),
- Help shape the working and living environment (3)
- Work scientifically in accordance with the "rules of good scientific practice" (2),
- Present technical content (2) and present it to an audience in correct technical language (2).

Teaching materials provided

Script, exercises, bibliography

Teaching media

Blackboard, overhead projector, computer, projector

Literature

- Shahinpoor, M. (Ed.). (2020). Fundamentals of Smart Materials. Royal Society of Chemistry, London, UK.
- Solymar, L., & Shamonina, E. (2009). Waves in metamaterials. Oxford University Press.

Further information about the course

In the course IMS, knowledge of the fundamentals of materials engineering from a Bachelor's degree programme to the extent of 3 ECTS is recommended.

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
LabVIEW projects	**LAP**

Responsible	Faculty
Prof. Dr. Heiko Unold	Electrical Engineering and Information Technology
Lecturer	Frequency
Prof. Dr. Heiko Unold	only in the summer semester

Teaching format
Seminar-based teaching for compulsory elective modules in specific subjects; project-based internship

Semester of study according to the curriculum	Scope of teaching [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	German	5

Time commitment:

Classroom study	Independent study
60	Independent project work: 40 hours; Documentation: 50 hours

Study and examination performance
See elective module catalogue for Master's in *Electrical and Microsystems Engineering*
Approved aids for performance assessment
See study plan table

Contents
The course is project-based, with the aim of building a functional complete system with LabVIEW. At the beginning, students choose a project that they will implement independently as part of the course. Projects can be selected from a list of suggestions or proposed by the students themselves. Projects that have a concrete connection to current problems (e.g. in OTH laboratories). The level of difficulty/scope of the projects is adjusted according to prior knowledge; for larger projects, groups of 2-3 students should be formed. Assessment is based primarily on the documentation of the software and hardware solution and its functionality. A realistic project plan, a presentation on the interim status and a final presentation will also be included in the assessment. The projects will be supervised during contact hours. If necessary, teaching units on relevant topics in optoelectronics or LabVIEW programming will be offered.
Learning objectives: Professional competence
After successfully completing the submodule, students will be able to • pass a LabVIEW test analogous to CLAD with a minimum score of 40% (1) • independently create LabVIEW programmes with an efficient structure (e.g. event-based state machine) (3)

Learning objectives: Personal competence
After successfully completing the submodule, students will be able to • plan, track, adjust and present a project workflow (2) • create complete documentation of their project and give an appealing presentation tailored to the target audience (2)
Teaching materials provided
Laboratory equipment, computers, LabVIEW licence
Teaching media
Laboratory, projector
Literature
• Georgi; Metin: Introduction to LabVIEW, Hanser-Verlag 2005 • Mütterlein: Handbook for Programming with LabVIEW, Springer-Verlag 2007 Hobbs: Building Electro-Optical Systems, John Wiley & Sons, 2009 • Hobbs: Building Electro-Optical Systems, John Wiley & Sons, 2009
Further information about the course
Recommended prior knowledge: Basics of LabVIEW programming; basics of optoelectronics

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
LED Technology (dual)	**LED**

Responsible	Faculty
Prof. Dr Johannes Wild Alexander Neumüller (LB)	Applied Natural and Cultural Sciences
Lecturer	**Frequency**
Alexander Neumüller (LB)	only in the summer semester
Teaching format	
Seminar-based teaching for compulsory elective modules in specific subjects	

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	English	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
See elective module catalogue for Master's in *Electrical and Microsystems Engineering*
Approved aids for performance assessment
See study plan table

Contents
• Semiconductor basics for LEDs • Material systems for LEDs • Photometric and radiometric values, candela, lumen; spectrum, "colour", "white", CRI, colour temperature • Chip technology, fundamental properties: TSN, InGaAlP, InGaN (energy band model/wavelength areas; substrates); chip production; electrical, optical, and thermal properties; chip size/current density/low current types; light extraction • Package technology: Leaded, premoulded, moulded, etc.; Requirements (solderability, SSLT, …; ESD stability, ESD protection; ageing, lifetime) • LED production: Assembly; Testing, binning; Measuring accuracy and tolerances • White light with LEDs: RGB (pros and cons); White conversion (properties, realisation; volume conversion, chip level conversion; colour homogeneity, white impression; white warm white) • Conversion • Phosphors and their properties • Non-saturated colours • Full conversion • Application of LEDs: General aspects (current feed, derating; durability; eye safety), automotive (interior/exterior, requirements, solution), projection; backlight units (SRGB, Adobe; RGB/conversion solutions; new opportunities: sequential colouring), flash, general lighting (special requirements; new solutions/retrofits)
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to **Knowledge:** • Students have knowledge about standard application conditions (level 1), the resulting requirements for an LED (level 2), and the necessary electrical, thermal, and optical design (level 2). **Skills:** • Students are able to describe the main peculiarities for creation of an LED, its properties and reasons for the brightness increase compared to classic light bulbs. (Level 1) • They can describe the main fabrication processes (level 2); material specialities (level 2) and features for light extraction increase (level 3).
Teaching materials
Blackboard, notebook, projector
Literature

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
Multi-processor and multi-core design for reliable embedded systems	**DRES**

Responsible	Faculty
Prof. Dr Johannes Wild Prof. Dr. Vooi Voon Yap	Applied Natural and Cultural Sciences
Lecturer	**Frequency**
Prof. Dr. Vooi Voon Yap	Winter semester only

Teaching
Seminar-based teaching for compulsory elective modules in specific subjects

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	English	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
See the elective module catalogue for the Master's programme in *Electrical and Microsystems Engineering*
Approved aids for performance assessment
See study plan table

Contents

Topic 1:

- A review of a single core design
- datapath,
- pipelining, and
- cache design

Topic 2:

- Multi-core COTS Processor
- Improving performance
- Multi-processor vs. multi-core: similarities and differences
- Maintaining design integrity when migrating from a single-processor solution
- Improving reliability
- Creating an “event processor”. Avoiding resource conflicts in multi-core designs

Topic 3:

- Introduction to OpenMP programming and MPI

Topic 4:

- Design challenges
- Scheduling issues
- Maintenance
- Adapting task sets for distributed systems. Example automotive control system

Topic 5:

- Timing issues
- Impact of jitter
- Different forms of clock synchronisation algorithm. Assessing what happens when something goes wrong
- Timing in the event of errors

Topic 6:
Controller Area Network (CAN) Protocol

- Creating a simple multi-processor design using CAN
- Challenges of clock synchronisation
- Timing of tasks and network communications
- Basic use of watchdogs
- Running without clock synchronisation

Topic 7:

- Improving reliability in distributed designs
- Adding redundant master nodes
- Adding redundant slave nodes
- Hot standbys
- Adding redundant communication paths. Bus vs. star topologies
- Compare performance of different architectures

- Safety integrity levels

Learning objectives: Professional competence
After successfully completing this sub-module, students will be able to **Knowledge:** • Students gain knowledge related to designing reliable embedded systems using multiprocessor and multicore processors. **Skills:** • The students gain skills in building embedded hardware programming in C for embedded systems. **Competences:** • Students gain competences in programming in C for embedded systems.
Teaching materials
Blackboard, notebook, projector
Literature
M.J. Pont, The Engineering of Reliable Embedded Systems M.J. Pont, Patterns for Time Triggered Embedded Systems
Further information about the course
Block course

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Overview of semiconductor fabrication in a high-volume environment	**IFX**

Responsible	Faculty
Prof. Dr. Corinna Kaulen	Applied Natural and Cultural Sciences
Lecturer	**Frequency**
Various lecturers from industry and academia	Only in the winter semester
Teaching format	
Seminar-based teaching for compulsory elective modules in specific subjects	

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	English	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
See the elective module catalogue for the Master's programme in *Electrical and Microsystems Engineering*
Approved aids for performance assessment
See study plan table

Contents
Overview of semiconductor fabrication in a high-volume environment Aspects of innovation in front-end and back-end towards high TRL Application examples include • Magnetic sensing (working principle, comparison of AMR, GMR, TMR and Hall technologies, practical examples of systems) • Automotive power switches (requirements for power electronics, technology features) • Chip cards and ID (products, function and requirements focusing on package technologies) Single process development and engineering • Transfer of process requirements to equipment and process recipe • Process characterisation and process control concept • Key performance indicator of a unit process and a semiconductor production • Dependencies and Cooperation towards quality management and technology development • Process control automation, digitalisation and optimisation of engineering • ISO9001, IATF16949 standards in quality management systems, auditing, deviation and risk management Overview of wafer testing processes, reliability failure mechanisms in packaging technologies, related standards and regulations, automatic optical inspection, and pre-assembly steps (tape & reel process, wafer dicing & grinding, process coupling) Methods for electrical failure verification and localisation, physical failure preparation and visualisation techniques Soft skills, introduction to project management in a technical environment, problem-solving methods (6 Sigma or 8D reporting for deviation management)
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to • Students understand the main steps involved in high volume manufacturing of semiconductors in a CMOS Fab including the interaction of different aspects from innovation to reliability (3). • They can describe selected applications, unit process requirements and monitoring concepts (2).
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to • classify the usefulness of the material learned. (2) • discuss subject-specific content in learning groups. (2) • analyse simple arguments and describe their own problems. (2) • assess the personal usefulness of various materials and learning methods. (3)
Teaching materials provided
Script (pdf slidedeck of presentations)
Teaching media
Projector, whiteboard

Literature
Literature will be announced during the course.

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
Physics of Semiconductor Devices Devices)	**BEP**

Responsible	Faculty
Prof. Dr. Rainer Holmer	Electrical Engineering and Information Technology
Lecturer	**Frequency**
Prof. Dr. Rainer Holmer	Winter semester only

Teaching
Seminar-based teaching for compulsory elective modules in specific subjects

Semester according to the study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1, 2, 3	4 SWS	German	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
See elective module catalogue for Master's in *Electrical and Microsystems Engineering*
Approved aids for performance assessment
See study plan table

Contents

- Fundamental principles of quantum mechanics
- Semiconductor physics: Crystal structure, band structure, semiconductor statistics, charge transport, generation and recombination
- Semiconductor diode: pn junction, high injection, temperature behaviour, breakdown behaviour, switching behaviour, metal-semiconductor contact
- Bipolar transistor: Functional principle, current amplification, characteristic curves, switching behaviour, models
- Field-effect transistor: MOS capacitor, MOSFET, characteristic curves, switching behaviour, models

Learning objectives: Technical expertise

After successfully completing this submodule, students will be able to

- Apply in-depth knowledge of the physical relationships in semiconductors (solid state physics, quantum mechanical fundamentals) to analyse semiconductor structures (3)
- Interpret the physical relationships at the pn junction (3)
- Handle the basic function and characteristics of bipolar and field-effect transistors (2)
- To create a basic physical description of the component behaviour of diodes, bipolar transistors and field-effect transistors (2)
- Perform simple device simulations (2) and interpret them (3)

- Use models for circuit simulation (2)
- Assess the functionality of electronic components and their physical limitations and
- constraints (3)
- The applicability of device simulations and models to specific problems (3)

Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to See preamble
Teaching materials provided
Lecture notes, bibliography
Teaching media
Blackboard, notebook, projector
Literature
/1/ F. Thuselt: "Physics of Semiconductor Devices", Springer, 2018 /2/ Sze S.M., Li, Y., Ng K.K.: Physics of Semiconductor Devices, Wiley, 2021 /3/ R. Müller: "Fundamentals of Semiconductor Electronics", Springer, 5th edition, 1987 /4/ C. Kittel: Introduction to Solid State Physics, Oldenbourg, 2024 /5/ M. Reisch: "Electronic Components", Springer, 2nd edition, 2007

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Quantum Theory and Information	**QTH2**

Responsible	Faculty
Prof. Dr. Ioana Serban	Applied Natural and Cultural Sciences
Lecturer	Frequency
Prof. Dr. Ioana Serban	Summer semester only
Teaching	
Seminar-based teaching for compulsory elective modules in specific subjects	

Semester of study according to the curriculum	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1, 2, 3	4 SWS	German	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
See elective module catalogue for Master's in *Electrical and Microsystems Engineering*
Approved aids for performance assessment
See study plan table

Contents

1. Mathematical fundamentals

2. Structure of quantum mechanics

- Mathematical structure, operators as matrices
- Postulates
- Schrödinger equation
- Unitary dynamics of quantum systems

3. Simple systems: quantum bits

- Spin 1/2, Pauli operators, Bloch sphere
- Photon polarisation, beam splitter, interferometer
- Quantum gates for single qubit systems

4. Entanglement

- Multiparticle systems, product space, vectors, operators
- EPR paradox
- Bell's inequalities
- Hong-Ou-Mandel effect

5. Quantum cryptography

- No-cloning theorem, CNOT gate
- Vernam encryption
- B92 protocol
- Teleportation

6. Quantum computer

- Quantum parallelism
- Physical implementations of gate-based quantum computers
- Algorithms
- Adiabatic quantum computing

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1. Mathematical basics

2. Structure of quantum mechanics

- Mathematical structure, operators as matrices
- Postulates
- Schrödinger equation
- Unitary dynamics of quantum systems

3. Simple systems: quantum bits

- spin 1/2, Pauli operators, Bloch sphere
- photon polarisation, beam splitter, interferometer
- quantum gates for single qubit systems

4. Entanglement

- multiparticle systems, product space, vectors, operators
- EPR paradox
- Bell inequalities
- Hong-Ou-Mandel effect

5. Quantum cryptography

- no-cloning theorem, CNOT gates
- Vernam encryption
- B92 protocol
- teleportation

6. quantum computing

- quantum parallelism
- physical realisations of gate-based quantum computers
- algorithms
- adiabatic quantum computing

Learning objectives: Professional competence

After successfully completing this submodule, students will be able to
- understand the physical principles prevailing in the quantum world (superposition, entanglement, uncertainty principle) (2)
- understand the mathematical foundations and properties of operators (1)
- calculate with spin operators (3), name the properties of qubits (1) and understand the function of quantum gates (2)
- to verify the existence of entanglement in simple systems by calculation (3) and to classify the effects based on this (2)
- understand quantum cryptography (2) and evaluate its advantages over classical cryptography methods (3)
- Critically evaluate the advantages of quantum computers over classical computers (3)

After successful completion of the submodule, students will be able to:
- understand the physical principles prevailing in the quantum world (superposition, entanglement, uncertainty principle) (2)
- understand the mathematical foundations and the properties of operators (1)
- calculate with spin operators (3), name the properties of qubits (1) and understand the function of quantum gates (2)
- check the existence of entanglement in simple systems by calculation (3) and classify effects based on it (2)
- understand quantum cryptography (2) and evaluate its advantages over classical cryptographic methods (3)
- critically evaluate advantages of quantum computers over classical computers (3)

Learning objectives: Personal competence

After successfully completing the sub-module, students will be able to
- classify the usefulness of the material learned. (2)
- Discuss subject-specific content in learning groups. (2)

- Recognise and evaluate learning progress. (2)
- Analyse simple arguments and describe their own problems. (2)
- Assess the personal usefulness of various materials and learning methods. (3)

After successful completion of the submodule, students will be able to:

- classify the benefits of the learned material (2)
- discuss technical content in study groups (2)
- recognise and evaluate learning progress (2)
- analyse simple arguments and describe their own problems (2)
- assess the personal benefit of different materials and learning methods (3)

Teaching materials provided

Script with a collection of tasks

Teaching media

Blackboard, notebook, projector

Literature

- Tipler: Modern Physics, Spektrum-Verlag
- D. Griffiths: Quantum Mechanics, Pearson
- F. Kuypers: Quantum Mechanics, Wiley-VCH

Further information about the course

Prerequisites: Knowledge of mathematics (helpful: linear algebra), mechanics (energy, momentum)

Requirements: knowledge of mathematics (helpful: linear algebra), mechanics (energy, momentum)

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
Surface Engineering of Semiconductor Materials	**SE**

Responsible	Faculty
Prof. Dr. Corinna Kaulen	Applied Natural and Cultural Sciences
Lecturer	Frequency
Prof. Dr. Corinna Kaulen	Winter semester only

Teaching
Seminar-based teaching for compulsory elective modules in specific subjects

Semester according to the study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	English	5

Time commitment:

Classroom study	Independent study
60	90

Study and examination performance
See elective module catalogue for the Master's programme in *Electrical and Microsystems Engineering*

Contents

- Engineering of Semiconductor Surfaces is an interdisciplinary subject covering different aspects of physics, chemistry, and nanotechnology.
- Fabrication and properties of silicon wafers
- Steps required in chip fabrication: cleaning, thin film deposition, application of structures and etching.
- Chemical surface modifications
- Micro- and nanofabrication strategies: top-down techniques, lithography and bottom-up concepts based on self-assembly.
- Unconventional nano-patterning techniques: micro-contact printing, thermal nanoimprint lithography, nanosphere lithography, dip-pen lithography
- Methods for surface analysis and physical characterisation: contact angle measurement, scanning probe microscopy, ellipsometry, surface plasmon resonance, X-ray photoemission spectroscopy (XPS) and transmission electron microscopy (TEM)

Learning objectives: Professional competence

After successfully completing the submodule, students will be able to

- The students have a fundamental understanding of the processes which occur at the interface of a semiconducting material and gas, liquid or another material (2)
- They have the capability to work in this field as well as to perform research and development (3)
- the students are able to present solutions concerning the design of miniaturised electrical and mechanical devices (3)

- They know the preliminary steps in thin film deposition, and know different methods for structuring surfaces (1)
- Students can extract the essence of selected research articles and present recent advances in nanoelectronics and sensor concepts in class (3).

Learning objectives: Personal competence

After successfully completing the sub-module, students will be able to
- students get used to working in teams with other students (3)
- They get in touch with other people's working culture and together they find a way to successfully deal with the practical tasks (3)
- They acquire key skills such as teamwork and managing conflicts in a productive way (3)
- They strengthen cooperative organising, intercultural competences and working independently in a team (3)

Teaching materials offered

Collection of lecture slides and exercise questions

Teaching media

Projector, blackboard

Literature

- Introduction to Microfabrication, S. Franssila, Wiley (2010)
- Chemical Vapour Deposition, X.-T- Yan, Springer (2006)

Further information about the course

Recommended prior knowledge: Basic knowledge of chemistry, e.g. successful completion of the basic module course "Engineering Chemistry"

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Theoreti c a l Electrical Engineering	**TET**

Responsible	Faculty
Prof. Dr. Mikhail Chamonine	Electrical Engineering and Information Technology
Lecturer	Frequency
Prof. Dr. Mikhail Chamonine Prof. Oliver Sterz	Every semester
Teaching format	
Seminar-based teaching with approx. 15% practical component, simulation at computer workstations.	

Semester of study in accordance with the curriculum	Scope of teaching [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	German	5

Time commitment:

Classroom study	Independent study
56	62 hours of preparation and follow-up work, 32 hours Exam preparation

Study and examination performance
See elective module catalogue for Master's in *Electrical and Microsystems Engineering*
Approved aids for performance assessment
See study plan table

Contents

Introduction

- Maxwell's equations in differential and integral form.
- Classification of electromagnetic problems.
- Classification of differential equations and boundary conditions.
- Helmholtz's theorem
- Uniqueness theorem

Electrostatics

- Electric potential
- Laplace and Poisson equations
- Work and energy in electrostatics
- Conductive bodies
- Potentials of different charge arrangements. Multipole expansion
- Specific solution methods for Laplace's equation

Magnetostatics

- Magnetic potentials
- Continuity conditions
- Multipole development for the vector potential
- Inductance

Electric and magnetic fields in matter

- Field of a polarised object
- Field of a magnetised object

Fields that change slowly over time

- Skin effect, eddy currents

Conservation laws

- Conservation of charge
- Energy conservation. Poynting's theorem
- Maxwell's stress tensor
- Angular momentum

Electromagnetic waves

- Wave equation
- Plane waves. Solutions for different materials. Skin depth
- Refraction and reflection. Surface wave
- Waveguide

Radiation

- Dipole radiation

- Point charges

Learning objectives: Technical expertise

After successfully completing the sub-module, students will be able to
- understand the fundamental concepts and technical terms of electrodynamics. (1)
- understand conservation laws. (1)
- Describe electromagnetic phenomena mathematically on the basis of fundamental physical quantities using the fundamental equations of electromagnetism (Maxwell's equations) and solve the fundamental equations. (2)
- Draw qualitative conclusions from a small number of physical concepts and laws. (2)
- Understand and apply Maxwell's equations to calculate field distributions. (3)

Learning objectives: Personal competence

After successfully completing the sub-module, students will be able to
- analyse their own learning progress and learning needs (3) and, if necessary, derive courses of action from this (3),
- work together with others in a goal-oriented manner (2), understand their interests and social situation (2), deal with them rationally and responsibly and communicate with them (2), and help shape the world of work and life (3),
- work scientifically in accordance with the "rules of good scientific practice" (2), present specialist content (2) and present it to an audience using correct technical language (2).

Teaching materials provided

Exercises, reading list

Teaching media

Blackboard, overhead projector, computer, projector

Literature

- David J. Griffiths, Introduction to Electrodynamics, Fourth Edition, Cambridge University Press, Cambridge, UK, 2017
- Heino Henke, Electromagnetic Fields, Springer-Verlag, Berlin, Heidelberg, 2015.
- M. Nahvi, J.A. Edminister, Electromagnetics, Fifth Edition, McGraw Hill, 2019.
- Matthew N. O. Sadiku, Numerical Techniques in Electromagnetics with MATLAB®, CRCPress, Boca Raton, USA, 2009.

Further information about the course

Mandatory prerequisites: Overview of basic quantities in vector analysis and their significance. Correct calculation of basic quantities in vector analysis.

Recommended prior knowledge: Knowledge, skills and competences acquired in a course on fields, waves and lines worth at least 5 ECTS.

If necessary, the course will be held in English.

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
Advanced Microcontroller Technology for Master's (Advanced Microcontroller Techniques for Master)	**VMCM**

Responsible	Faculty
Prof. Dr. Florian Aschauer	Electrical Engineering and Information Technology
Lecturer	**Frequency**
Prof. Dr. Florian Aschauer	Every semester

Teaching format
Seminar-based teaching for compulsory elective modules in specific subjects (seminar and project work – 100% practical component)

Semester according to the study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	German	5

Time commitment:

Classroom study	Independent study
56	70 hours (preparation and follow-up); 24 hours (exam preparation)

Study and examination performance
See the elective module catalogue for the Master's programme in *Electrical and Microsystems Engineering*
Approved aids for performance assessment
See study plan table

Contents

- Internet research on the current state of the art
- Implementation of complex projects with microcontrollers from various manufacturers with ARM derivatives (Cortex M0, M3, M4), circuit design with simulation if necessary
- Circuit design (analogue/digital) / printed circuit board design / mechanical construction (soldering, including small SMD components) - Prototype construction / software development (Assembler / C / RTX-Keil)
- Creating an EI-WIKI entry and presenting the project

Learning objectives: Professional competence

After successfully completing the sub-module, students will be able to

- work with development environments (3)
- Implement hardware and software specifications using suitable hardware (2)
- Create circuit diagrams and printed circuit boards (e.g. using EAGLE) (2)
- Document the development process and created software (Doxygen) (2)
- Present results (interim and final presentation) (2)
- Be able to create online documentation (EI Wiki) (2)

Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to • approach problems systematically (2) • discuss and review results self-critically (1) • work in a team (2)
Teaching materials offered
EI Wiki (previous projects)
Teaching media
Computers, projectors, blackboards, flipcharts, evaluation boards, logic analysers, microscopes, 3D printers, soldering stations, EI Wiki
Literature
• Data sheets (English) for the processor used • Assembly language programming, ARM Cortex M3, Vincent Mahout, Wiley, 2012 • ARM assembly language with hardware experiments, Ara Elahi, Trevor Arjeski, Springer, 2015 • Introduction to ARM Cortex-M microcontrollers, Jonathan W. Valvano, 2015, Vol. 1 Original data sheets in English from the processor manufacturer

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Module name (English name if applicable)	Module code or no.
Additional training Occupational safety specialist - Safety Engineer (Modules PI-III) (Additional Training in Specialist for Occupational Safety - Safety Engineer)	ZFA /I 1

Module coordinator	Faculty
Gunter Nowack (LB) Prof. Dr Johannes Wild	General Science Programme Applied Natural and Cultural Sciences

Semesters of study according to the study plan	Study section	Module type	Workload [ECTS credits]
1, 2, 3		Focus Elective module	12

Compulsory prerequisites
See AW module catalogue
Recommended prior knowledge
See AW module catalogue

Contents

The training provides students of technical degree programmes with the necessary technical, methodological and social skills for safety-related and occupational health and safety tasks as future managers, supervisors or safety engineers. The objectives of this additional training are:

- Promoting entrepreneurial thinking and action
- Explaining the business aspects of starting a company
- Teaching business management for engineers
- Training entrepreneurial action in the start-up situation

Further details can be found in the course catalogue of the AW programme at OTH Regensburg.

Learning objectives: Personal competence

After successfully completing the module, students will be able to See AW module catalogue

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Assigned sub-modules:

No.	Name of sub-modules	Teaching scope [SWS or UE]	Workload [ECTS credits]
1.	Safety Engineer PI (Specialist for Occupational Safety - Safety Engineer PI)	2 SWS	2
2	Safety Engineer PII (Specialist for Occupational Safety - Safety Engineer PII)	2 SWS	3
3	Safety Engineer PIII (Specialist for Occupational Safety - Safety Engineer PIII)	4 SWS	4
4	Safety Engineer PIV (Specialist for Occupational Safety - Safety Engineer PIV)	2 SWS	4
5	Safety Engineer PV (Specialist for Occupational Safety - Safety Engineer PV)	2 SWS	2

Information on compulsory enrolment or options
The additional training course "Occupational Safety Specialist - Safety Engineer" is part of the AW programme programme at OTH Regensburg. Module description and registration via the AW programme homepage. To obtain the "Occupational Safety Specialist - Safety Engineer" certificate, all 5 sub-modules of the overall module must be completed. In the *interdisciplinary* focus, all 5 sub-modules **P I**, **P II**, **P III, P IV** and **P V** must be completed. 12 ECTS credits are credited to the Master's degree certificate. All 15 ECTS credits are documented with the additional certificate.

Submodule	TM abbreviation
Safety Engineer PI (Specialist for Occupational Safety - Safety Engineer PI)	**ZFA**

Responsible	Faculty
Prof. Dr Johannes Wild	Applied Natural and Cultural Sciences
Teacher/lecturer	Frequency
Gunter Nowack (LB)	Winter semester only
Teaching	
See AW module catalogue	

Semester according to study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	2 SWS	German	2

Time commitment:

Classroom study	Independent study
30	90

Study and examination performance
See AW module catalogue
Approved aids for performance assessment
See AW module catalogue

Contents
See AW module catalogue
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to See AW module catalogue
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to See AW module catalogue
Teaching materials offered
See AW module catalogue
Teaching media
See AW module catalogue
Literature
See AW module catalogue

Further information on the course
See AW module catalogue

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
Safety Engineer PII (Specialist for Occupational Safety - Safety Engineer PII)	**ZFA**

Responsible	Faculty
Gunter Nowack (LB) Prof. Dr Johannes Wild	General Science Programme
Lecturer	**Frequency**
Reinhard Meier (LB) Gunter Nowack (LB)	
Teaching format	
See AW catalogue	

Semester according to study plan	Scope of teaching [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	2 SWS	German	3

Time commitment:

Classroom study	Independent study
30	60

Study and examination performance
See AW catalogue
Approved aids for performance assessment
See AW catalogue

Contents
See AW catalogue
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to See AW catalogue
Teaching materials offered
See AW catalogue
Teaching media
See AW catalogue
Literature
See AW catalogue

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
Safety Engineer PIII (Specialist for Occupational Safety - Safety Engineer PIII)	**ZFA**

Responsible	Faculty
Gunter Nowack (LB) Prof. Dr Johannes Wild	General Science Programme
Lecturer	**Frequency**
Gunter Nowack (LB)	
Teaching method	
See AW module catalogue	

Semesters of study according to the curriculum	Scope of teaching [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	4 SWS	German	4

Time commitment:

Classroom study	Independent study

Study and examination requirements
See AW module catalogue
Approved aids for performance assessment
See AW module catalogue

Contents
See AW module catalogue
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to See AW module catalogue
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to See AW module catalogue
Teaching materials offered
See AW module catalogue
Teaching media
See AW module catalogue
Literature
See AW module catalogue

Further information on the course
See AW module catalogue

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	**TM abbreviation**
Safety Engineer PIV (Specialist for Occupational Safety - Safety Engineer PIV)	**ZFA**

Responsible	Faculty
Gunter Nowack (LB) Prof. Dr Johannes Wild	General Science Programme
Lecturer	**Frequency**
Gunter Nowack (LB)	
Teaching format	
See AW module catalogue	

Semester according to study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	2 SWS	German	4

Time commitment:

Classroom study	Independent study
30	90

Study and examination performance
See AW module catalogue
Approved aids for performance assessment
See AW module catalogue

Contents
See AW module catalogue
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to See AW module catalogue
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to See AW module catalogue
Teaching materials offered
See AW module catalogue
Teaching media
See AW module catalogue
Literature
See AW module catalogue

Further information on the course
See AW module catalogue

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply

Submodule	TM abbreviation
Safety Engineer PV (Specialist for Occupational Safety - Safety Engineer PV)	**ZFA**

Responsible	Faculty
Gunter Nowack (LB) Prof. Dr Johannes Wild	General science programme
Teacher/Lecturer	**Frequency**
Gunter Nowack (LB)	

Teaching format
See AW module catalogue

Semester according to study plan	Teaching scope [SWS or UE]	Language of instruction	Workload [ECTS credits]
1st, 2nd, 3rd	2 SWS	German	2

Time commitment:

Classroom study	Independent study
30	30

Study and examination requirements
See AW module catalogue
Approved aids for performance assessment
See AW module catalogue

Contents
See AW module catalogue
Learning objectives: Professional competence
After successfully completing the sub-module, students will be able to See AW module catalogue
Learning objectives: Personal competence
After successfully completing the sub-module, students will be able to See AW module catalogue
Teaching materials offered
See AW module catalogue
Teaching media
See AW module catalogue
Literature
See AW module catalogue

Further information on the course
See AW module catalogue

The numbers in brackets indicate the levels to be achieved: 1 - know, 2 - can, 3 - understand and apply