HSB

Unterlagen

für das interne Akkreditierungsverfahren

des Studiengangs

Electronics Engineering M.Sc.

<u>Teil E</u>

Modulhandbuch

INTRODUCTION

For more than twenty years, Electronics Engineering M.Sc. (MScEE) has been established as a successful master's degree program at Bremen University of Applied Sciences. It is designed as an application-oriented, international degree program fully taught in English. Its disciplinary focus within in the field of Electronics Engineering lies on Intelligent Systems, providing an optional profile-building in either “Development and Fabrication of Intelligent Systems” or “Application of Intelligent Systems”. Regarding the study structure, the program offers customized study options for different target groups:

» For applicants with 180 ECTS from their first university (Bachelor’s) degree:
Four-semester program (120 ECTS), either as standard full-time student or as dual student (provided students have concluded a study contract with a cooperating partner company of Hochschule Bremen)
» For applicants with 180 ECTS from their first university (Bachelor’s) degree:
Three-semester program (90 ECTS), either as standard full-time students or as dual student (provided students have concluded a study contract with a cooperating partner company of Hochschule Bremen)

The curriculum consists mainly of Elective Modules: “Electronics Engineering Elective” is a container module for which students can select specific disciplinary modules from the Technical Electives Catalogue. Likewise, “Non-technical Elective” is a container module, for which specific interdisciplinary modules can be selected from the Non-Technical Electives Catalogue. Thus, the program is structured as follows:

Four-Semester Program Option			
	Three-semester Program Option		
1. Semester	2. Semester 1. Semester	3. Semester 2. Semester	4. Semester 3. Semester
1.1	2.1	3.1	4.1
Electronics Engineering Lab Elective 1	Electronics Engineering Elective 1	Electronics Engineering Elective 5	Master-Thesis 30 ECTS (P)
1.2	2.2	3.2	
Electronics Engineering Lab Elective 2	Electronics Engineering Elective 2	Electronics Engineering Elective 6	
1.3	2.3	3.3	
Scientific Techniques Elective	Electronics Engineering Elective 3	Electronics Engineering Elective 7	
1.4/1.5	2.4/2.5	3.4/3.5	
Non-dual: Electronics Engineering Project	Non-dual: Electronics Engineering Elective 4	Non-dual: Electronics Engineering Elective 8	
Dual: Theory-Practice-Project 1	Dual: Theory-Practice-Project 2	Dual: Theory-Practice-Project 3	
1.6	2.6	3.6	
(Language) Elective	Non-technical Elective 1	Non-technical Elective 2	

The Technical Elective Catalogue consists of 13 modules potentially to be offered in winter term and 14 modules potentially to be offered in summer term. The module offer per semester may vary.

Each module in the Technical Elective Catalogue is assigned to one or both of the study profiles “Development and Fabrication of Intelligent Systems” and “Application of Intelligent Systems”. To study with a profile, students need to complete four Technical Electives assigned to one profile and to write their Master thesis in a field matching the same profile. Studying with a profile is optional – students can also complete the program without profile-building.

TECHNICAL ELECTIVES CATALOGUE		
Study profiles: Development and Fabrication of Intelligent Systems = DEF, Application of Intelligent Systems = APP		
	DEF	APP
Potential module offers in winter term		
2.7 Microsystems and Transducers	x	
2.8 Measurement and Instrumentation		x
2.9 Statistical Signal Processing	x	x
2.10 Design and Realization of Mixed-technology Systems	x	x
2.11 Technical Optics	x	
2.12 Numerical Methods	x	x
2.13 Introduction to Systems Engineering		x
2.14 Fundamentals of Machine Learning	x	x
2.15 Hardware Implementation of AI	x	x
2.16 Satellite Communications		x
2.17 Applied autonomous driving		x
2.18 Selected Topics of Electronics Engineering 1	x	x
2.19 Electronics Engineering Project 1	x	x
Potential module offers in summer term		
3.7 Advanced Hardware Verification	x	
3.8 Computer Aided Data Acquistion	x	x
3.9 Information and Coding Theory		x
3.10 Microfabrication	x	
3.11 Fiber Optics	x	
3.12 Microwave Circuits and Systems	x	
3.13 Image Processing and Pattern Recognition		x
3.14 Advanced Topics of Lasers	x	
3.15 Underwater Acoustics and Sonar Signal Processing	x	
3.16 Wireless Communication		x
3.17 Microelectronic Circuit Design	x	x
3.18 Optical Metrology		x
3.19 Selected Topics of Electronics Engineering 2	x	x
3.20 Electronics Engineering Project 2	x	x
NON-TECHNICAL ELECTIVES CATALOGUE		
2.21 Intercultural Teambuilding I 3.21 Intercultural Teambuilding II		
2.22 Modern Concepts of Project Management I 3.22 Modern Concepts of Project Management I		
2.23 Engineering in Society I 3.23 Engineering in Society II		
2.24 Research Methods I 3.24 Research Methods II		
2.25 / 3.25 Sprachmodul Deutsch / Englisch		

On the following pages you can find the detailed module descriptions for each module.

1st SEMESTER (FOUR-SEMESTER PROGRAM)

1.1/1.2 ELECTRONICS ENGINEERING LAB 1 and 2

Module leader:	Prof. Dr. Friedrich Fleischmann		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Dual and non-dual program: Container module for technical lab electives	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in the 1. semester of the four-semester program	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

For this placeholder module, students are to select a specific module from the “Electronics Engineering Lab Elective” Catalogue. For students of non-dual variant, these are currently:

- 1.10 Engineering Lab
- 1.11 Data Analysis and Visualization

After successful completion of the two modules “Engineering Lab” and “Data Analysis and Visualization” students have extended and deepened their practical skills and knowledge in Electronics Engineering.
Students of dual variant pick two modules from technical electives catalogue. The individual module choice should be taken in consideration with the head of the program.
For detailed learning outcomes please see the module descriptions of each elective module.

Course content:

For course contents please see the module descriptions of each elective module.

Language of teaching:	English
Learning and teaching methods:	See respective elective
Prerequisites:	None
Preparation/literature:	See respective elective
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Electronics Engineering Lab 1 - 2	See respective elective	2	Seminar (S)	See respective elective
Electronics Engineering Lab 1 - 2	See respective elective	2	Laboratory (L)	

1.3 SCIENTIFIC TECHNIQUES ELECTIVE

Module leader:	Prof. Dr. Friedrich Fleischmann		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Dual and non-dual program: Container module for scientific techniques electives	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in the 1. semester of the four-semester program	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			/

For this placeholder module, students are to select a specific module from the "Scientific Techniques Elective" Catalogue. Students of dual variant pick module 1.13 "Efficient Programming", students of non-dual variant 1.12 "Academic Writing".

- 1.12 Academic Writing
- 1.13 Efficient Programming

Learning outcomes:

After completion of the selected Scientific Techniques Elective module, students have extended and deepened their practical skills in knowledge and application of essential scientific techniques relevant in Electronics Engineering. They are able to apply their knowledge and problem-solving skills in complex contexts within the scope of the specific module topic.

Course content:

For course contents please see the module descriptions of each elective module.

Language of teaching:	English
Learning and teaching methods:	See respective elective
Prerequisites:	None
Preparation/literature:	See respective elective
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Scientific Techniques	See respective elective	2	See respective elective	See respective elective
Scientific Techniques	See respective elective	2	See respective elective	

1.4 ELECTRONICS ENGINEERING PROJECT

Module leader:	Prof. Dr. Friedrich Fleischmann		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Non-dual program only: Mandatory module in the 1. semester of the four-semester program	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	Depending on the specific project	**Scope and frequency of teaching:**	14 classes in summer term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

After successful completion of this module the students are able to …

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- … identify and describe relevant project parameters like key engineering components, design tools and measurement equipment;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- … evaluate and structure a given project topic on EE regarding scheduling, monitoring and control;
- … do self-directed studies within running research projects on electronics engineering under guidance of project manager;
- … acquire knowledge and skills on given engineering topics by applying “learning by doing”

Communication and cooperation

- … work effectively in a team;
- … present scientific results on investigations, design and measurements
- … improve the outcome of group meetings and discussions;

Reflection of academic and professional identity

- … reflect system design and test setup with regard to alternative designs,
- … adhere to standards of professional action and documentation.

Course content:	▪ Introduction to EEP: Subjects are related to the Electronics Engineering program and are usually inspired by current research projects in institutes i3m, IWSS and IAT ▪ Methods on scientific investigations in electronics engineering using literature and internet support ▪ Team work ▪ Project implementation, scheduling, monitoring and control ▪ Function, performance and application of project relevant engineering components, design tools and measurement equipment within a defined research project on optics, electronics, microsystems, communications, measurement and instrumenta-tion ▪ Methods on evaluation of results, documentation and presentation techniques
Language of teaching:	English
Learning and teaching methods:	Project work
Prerequisites:	None
Preparation/literature:	References are announced at the beginning of the project.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Electronics Engineering Project	Professors of the pro-gram depending on project chosen	4	Project (P)	Project Work (PA)

1.5 THEORY-PRACTICE-PROJECT MODULE 1

Module leader:	Prof. Dr. Friedrich Fleischmann		
ECTS points:	6 ECTS	**Workload (h):**	360h
Type of module and position in the program:	Dual program only: Mandatory module in the 1. Semester of the four-semester program	**Project work at the cooperating company (h):**	180h (usually 1 day per week during semester)
Scope and frequency of teaching:	21h Academic Consulting in groups of 5 students (summer term)	**Contact hours at HSB (h):**	21h
		Self-study (h):	159h (project work)
Type of module and position in other study programs or continuing education offers:			/

In the dual variants of the program, the Theory-Practice-Project modules 1, 2 and 3 (TPP 1, TPP2 and TPP3) are designed to realize the mutual transfer between the scientific knowledge gained at university and the practical competencies acquired at the cooperating company. The modules are interconnected, as students conduct an individual industrial project that stretches over two (in the four-semesters program possibly three) semesters, thus preparing them for the master's thesis, which is carried out as a practice project at the cooperating company in the last semester. The specific application reference in the TPP module is influenced by the needs of the respective partner company and is specified in consultation between the university, company and students.

TPP module are completed at the two learning locations involved in dual studies, combining project work at the cooperating company with accompanying Academic Project Consulting at HSB.

Learning outcomes:

After completion of the TPP modules, students have gained scientific and methodological skills in order to transfer the theoretically acquired specialist knowledge into the technical requirements and processes in their partner company and, conversely, to work on company-specific tasks in a structured and scientifically sound manner.

They are specifically able to

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- formulate their own scientific questions;
- carry out scientific research in a practical industrial setting;
- correctly summarize the state of the art in science and technology, establish essential references to the previously defined question and present own findings and conclusions;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- search for relevant information for decision-making on the basis of an incomplete information base;
- draw scientifically sound conclusions or make decisions from this information, also considering social and ethical findings;

Communication and cooperation

- critically reflect on the findings of others from a scientific perspective and give feedback;
- deal constructively with direct criticism of content;

Reflection of academic and professional identity

- adhere to standards of professional action and documentation;
- pursue their learning and work objectives in a self-directed way;
- place technological approaches in a social context, discuss and evaluate them.

Course content:	In the Academic Project Consulting, professors of the program accompany the industrial project work of the students with regular meetings in small groups on the design and continuous review of the project structure. This creates a forum for professional and organizational exchange, as well as a framework for the scientific support of the student's work, which ensures the transfer of knowledge in both directions.
Language of teaching:	English
Prerequisites:	None
Preparation/literature:	None
Further information:	

Courses of the module				
Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching form**	**Examination method(s), scope and duration**
Theory-Practice-Project 1: Academic Project Consulting	Professors of the program	1,5	Acad. Consulting (max 5 students per unit)	Project work (PA)

1.6 (LANGUAGE) ELECTIVE

Module leader:	Prof. Dr. Friedrich Fleischmann (conducted at Fremdsprachenzentrum Bremen)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Dual and non-dual program: Container module for (language) electives	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in the 1. semester of the four-semester program	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			/

Students who do not have at least C1 level according to the Common European Framework of Reference for Languages take a German language course. Students with appropriate German language skills take an elective module.

Learning outcomes:

After completion of the selected Language Elective module, students have extended and deepened their practical skills in German language or non-technical elective.

In case of taking an elective module, please see the module descriptions of the chosen module for detailed learning outcomes.

Course content:

For course contents please see the module descriptions of each elective module.

Language of teaching:	English
Learning and teaching methods:	See respective elective
Prerequisites:	None
Preparation/literature:	See respective elective
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
(Language) Elective	See respective elective	2	See respective elective	See respective elective
(Language) Elective	See respective elective	2	See respective elective	

1.10 ENGINEERING LAB

Module leader:	Prof. Dr. Friedrich Fleischmann		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Non-dual program: Elective module for technical lab	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in the 1. semester of the four-semester program	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

After successful completion of the module students have extended and deepened their practical skills and knowledge in Electronics Engineering. Specifically, they are able to …

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- … identify and describe relevant project parameters like impact of components, relevant boundary conditions and measurement equipment;
- … are able to use NIST-GUM,

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- … design, assemble and conduct meaningful experiments,
- … acquire knowledge and skills on given engineering topics by applying “learning by doing”,
- … document all relevant conditions and actions for repeatability,
- … apply statistical methods to evaluate significance of measurement results,
- … analyse and visualize data scientifically,

Communication and cooperation

- … do project work in a team,
- … decide autonomous about organization and conduct of experiments,
- … present progress and results to supervisors and peers,
- … assess results from experiment, evaluate in team and document scientifically,

Reflection of academic and professional identity

- … reflect system design and test setup with regard to alternative designs,
- … adhere to standards of professional action and documentation.

Course content:

- Concepts of standards in international context
- Statistics, types of error, sources of error, measurement uncertainty
- Design of experiments
- Static and dynamic behaviour of measuring setup
- Scientific documentation of setup and procedure
- Regression, goodness of fit, global and local interpolation, spline interpolation.

Language of teaching:	English
Learning and teaching methods:	Seminar: Seminar talk and discussion Laboratory: Project like experimental lab work
Prerequisites:	None
Preparation/literature:	NIST-GUM; additional papers to be handed out according to lab tasks
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Engineering Lab	tba	2	Seminar (S)	Lab-integrating written (90 mins) or oral (30 mins) examination (IP)
Engineering Lab	tba	2	Laboratory (L)	

1.11 DATA ANALYTICS AND VISUALIZATION

Module leader:	Prof. Dr. Friedrich Fleischmann		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Non-dual program: Elective module for technical lab	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in the 1. semester of the four-semester program	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

After successful completion of the module students have extended and deepened their practical skills and knowledge in Electronics Engineering. Specifically, they are able to ...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... identify and describe relevant project parameters like impact of system setup, relevant boundary conditions and measurement equipment;
- ... are able to use numerical tools for data evaluation;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... acquire knowledge and skills on given engineering topics by applying “learning by doing”,
- ... document all relevant conditions and actions for repeatability,
- ... apply statistical methods to evaluate significance of measurement results,
- ... analyse and visualize data scientifically,

Communication and cooperation

- ... do project work in a team,
- ... decide autonomous about organization and conduct of experiments,
- ... present design decision, progress and results to supervisors and peers,
- ... assess results from experiment, evaluate in team and document scientifically,

Reflection of academic and professional identity

- ... reflect data selection and evaluation concept with regard to alternative designs,
- ... reflect and adhere to standards of professional action and documentation,
- ... recognize data visualizations as elements of good scientific practice and take into account the rules of good scientific practice with regard to the use of data sources,
- ... reflect on data visualizations as digital design objects with regard to their interpretative and suggestive potentials in terms of media ethics and media criticism.

Course content:

- Scientific documentation of data base and evaluation procedure;
- Quantitative and qualitative information;
- Research and data analysis;
- Principle of design and methodology of data visualization;
- Regression methods, goodness of fit, global and local interpolation, spline interpolation.

Language of teaching:	English
Learning and teaching methods:	Seminar: Seminar talk and discussion Laboratory: Project like experimental lab work
Prerequisites:	None
Preparation/literature:	• Claus O. Wilke, Fundamentals of Data Visualization, O’Reilly • Jake VanderPlas. Python Data Science Handbook: Essential Tools for Working with Data, O’Reilly Media, 2016 • Sandeep Nagar, Introduction to Python for Engineers and Scientists, Apress • Darrell Huff, Irving Geis, How to Lie with Statistics, W.W. Norton
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Data Analytics and Visualization Seminar	tba	2	Seminar (S)	Lab-integrating written (90 mins) or oral (30 mins) examination (IP)
Data Analytics and Visualization Lab	tba	2	Laboratory (L)	

1.12 ACADEMIC WRITING

Module leader:	Tanja Müller		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Non-dual program students: Mandatory module taught in the 1. semester	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in summer term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

After successful participation in the module course, students will be able to explain and apply essential techniques of scientific work and writing. These are applied to a self-chosen question on the field of electronics engineering. Specifically, they are able to...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... analyze the content of a relevant section of a given subject area with regard to typical issues and discussions in the scientific community;
- ... penetrate the content of a given subject area with regard to typical issues and discussions in the scientific community and
- summarize in a scientifically correct manner and establish essential links between the sub-aspects;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... correctly transfer the acquired knowledge (theory/findings) to other examples or application domains of their choice correctly;
- ... starting from an incomplete information base, search specifically for relevant information for a research relevant information for decision making and from this draw scientifically sound conclusions;

Communication and cooperation

- ... present results and conclusions regarding scientific text genres to peer group;
- ... discuss and defend results;

Reflection of academic and professional identity

- ... reflect data selection and evaluation concept with regard to alternative designs.

Course content:

- Methods and techniques of scientific writing
- Systematic literature research including scientific databases
- Reviewing state of articulate
- Arguing, correct referencing and citing
- Writing cycle (Drafting-Feedback-Revising)
- Scientific genres: Abstract, expose, report, article, protocol
- Presentation techniques

Language of teaching:	English
Learning and teaching methods:	Seminar talk, project work and discussion
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Academic Writing	T. Müller	4	Seminar	Portfolio (PF)

1.13 EFFICIENT PROGRAMMING

Module leader:	Dr. David Hilbig		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual program: Mandatory module taught in the 1. semester	**Contact hours (h):**	56h
Scope und frequency of teaching:	14 classes in summer term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

This module covers various topics of efficient programming using a programming language such as C and C++. It provides students with a wide-ranging toolset for numerical tasks in embedded control, data analysis, signal processing, modelling and simulation. These are the backbone of numerous applications in the areas of data sciences, machine learning, computer graphics and engineering. One focus will be set on the efficient implementation of numerical algorithm. It further includes topics of integration, optimization and solving systems of equations.

The module follows a hands-on approach in which newly learned content will be directly implemented in code and tested using various examples for a deeper understanding of the topic. Implementation and testing are carried out in a dedicated work environment on the students' own computer.

After completion of the module the students are able to ...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... name and distinguish between language structure elements;
- ... consider the impact of numerical approximations and limited machine precision in computations;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... create procedural programs for the analysis, evaluation and presentation of data independently.
- ... analyze mathematical, scientific and technical problems and calculate solutions using self-developed algorithms;
- ... develop and program algorithms for numerical data analysis;
- ... create suitable numerical models based on a given problem;
- ... work efficiently with C/C++ tools and packages related to numerical programming;

Communication and cooperation

- ... work efficiently in a team of multi-cultural and international members
- ... divide workload between members of a team

Reflection of academic and professional identity

- ... pursue a critical assessment of results provided by prebuild numerical solutions.

Course content:

- Data types, operators, expressions
- Control structures and their description
- Pointers, arrays, strings, memory, structures and unions
- I/O
- Object orientation (classes, objects, data abstraction, methods, reference data types, inheritance, interfaces, polymorphism),
- Numerical Integration & Differentiation
- Interpolation and Optimization
- Discrete Fourier Transform & Convolution

Language of teaching:	English
Learning and teaching methods:	Seminar: Seminaristic teaching, discussion, coding sessions Laboratory: Experimental lab work
Prerequisites:	none
Preparation/literature:	▪ Mark Weiss, Efficient C Programming: A Practical Approach, Pearson ▪ Brian Kernighan; Dennis Ritchie, The C Programming Language, Prentice Hall ▪ Bjarne Stroustrup, Programming: Principles and Practice Using C++, Pearson
Further information:	AULIS link will be sent to students at the start of the respective course.

Courses of the module				
Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching form**	**Examination method(s), scope and duration**
Efficient Programming	David Hilbig	2	Seminar (S)	Portfolio (PF)
Efficient Programming	David Hilbig	2	Laboratory (L)	

1.14 LANGUAGE MODULE GERMAN

Module leader:	Prof. Dr. Friedrich Fleischmann (conducted at Fremdsprachenzentrum Bremen)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Non-technical elective module taught in the 1. semester	**Contact hours (h):**	56h
Scope und frequency of teaching:	14 classes in 1. semester of the four-semester program	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			/
Learning outcomes: German courses refer to the Common European Framework of Reference (CEFR); learning outcomes are given here for level A 1: Can understand and use familiar everyday expressions and very basic phrases aimed at the satisfaction of needs of a concrete type. Can introduce him/herself and others and can ask and answer questions about personal details such as where he/she lives, people he/she knows and things he/she has. Can interact in a simple way provided the other person talks slowly and clearly and is prepared to help.			
Course content:	Courses are taught on the basis of a course book (see literature)		
Language of teaching:	German/English		
Learning and teaching methods:	Language exercises in individual and group work, case studies, group projects, presentations and discussions		
Prerequisites:	Completion of the previous level		
Preparation/literature:	Course book for levels A 1 – B 1: “Netzwerk”, Klett-Verlag (to be purchased by students)		
Further information:	AULIS link will be sent to students at the start of the respective course.		

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
German Language Module (conducted at Fremdsprachenzentrum Bremen/FZHB)	German lecturers from FZHB	4	Seminar	Written exam (KL) or oral exam (MP)

2nd/1st and 3rd /2nd SEMESTER (FOUR-/THREE-SEMESTER PROGRAM)

2.1 – 2.4 and 3.1 – 3.4 ELECTRONICS ENGINEERING ELECTIVE 1 – 8

Module leader:	Prof. Dr. Friedrich Fleischmann		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the course of study:	Dual and non-dual program: Container module for technical electives	**Contact hours (h):**	56h
Scope and frequency of teaching:	14 classes in the 2. or 3. semester of the four-semester program 14 classes in the 1. or 2. semester of the three-semester program	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			/

For this placeholder module, students are to select a specific module from the “Technical Electives Catalogue”.

The program can be studied with a study profile in either “Development and Fabrication of Intelligent Systems” or “Application of Intelligent systems”, if they complete at least four technical elective modules assigned to one profile and write their Master’s thesis in a field matching the same profile. The respective study profile will be specified in the graduation certificate.

For each Technical Elective it is marked in the module description which profile(es) (one or both) it is assigned to.

Learning outcomes:

After completion of the selected Technical Elective module, students have extended and deepened their knowledge and understanding in Electronics Engineering with a focus on Intelligent Systems. They are able to apply their knowledge and problem-solving skills in complex contexts within the scope of the specific module topic.

For detailed learning outcomes please see the module descriptions of each elective module.

Course content:

For course contents please see the module descriptions of each elective module.

Language of teaching:	English
Learning and teaching methods:	See respective elective
Prerequisites:	None
Preparation/literature:	See respective elective
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Electronics Engineering Elective 1 – 8 (container module)	See respective elective	2	See respective elective	See respective elective
Electronics Engineering Elective 1 – 8 (container module)	See respective elective	2	See respective elective	

2.5 and 3.5 THEORY-PRACTICE-PROJECT MODULES 2 and 3

Module leader:	Prof. Dr. Friedrich Fleischmann		
ECTS points:	6 ECTS	**Workload (h):**	360h
Type of module and position in the program:	Dual program only: Mandatory module	**Project work at the cooperating company (h):**	180h (usually 1 day per week during semester)
Scope and frequency of teaching:	21h Academic Consulting in groups of 5 students (summer or winter term)	**Contact hours at HSB (h):**	21h
		Self-study (h):	159h (project work)
Type of module and position in other study programs or continuing education offers:			/

In the dual variants of the program, the Theory-Practice-Project modules 1, 2 and 3 (TPP 1, TPP2 and TPP3) are designed to realize the mutual transfer between the scientific knowledge gained at university and the practical competencies acquired at the cooperating company. The modules are interconnected, as students conduct an individual industrial project that stretches over two (in the four-semesters program possibly three) semesters, thus preparing them for the master's thesis, which is carried out as a practice project at the cooperating company in the last semester. The specific application reference in the TPP module is influenced by the needs of the respective partner company and is specified in consultation between the university, company and students.

TPP module are completed at the two learning locations involved in dual studies, combining project work at the cooperating company with accompanying Academic Project Consulting at HSB.

Learning outcomes:

After completion of the TPP modules, students have gained scientific and methodological skills in order to transfer the theoretically acquired specialist knowledge into the technical requirements and processes in their partner company and, conversely, to work on company-specific tasks in a structured and scientifically sound manner.

They are specifically able to

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- formulate their own scientific questions;
- carry out scientific research in a practical industrial setting;
- correctly summarize the state of the art in science and technology, establish essential references to the previously defined question and present own findings and conclusions;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- search for relevant information for decision-making on the basis of an incomplete information base;
- draw scientifically sound conclusions or make decisions from this information, also considering social and ethical findings;

Communication and cooperation

- critically reflect on the findings of others from a scientific perspective and give feedback;
- deal constructively with direct criticism of content;

Reflection of academic and professional identity

- adhere to standards of professional action and documentation;
- pursue their learning and work objectives in a self-directed way;
- place technological approaches in a social context, discuss and evaluate them.

Course content:	In the Academic Project Consulting, professors of the program accompany the industrial project work of the students with regular meetings in small groups on the design and continuous review of the project structure. This creates a forum for professional and organizational exchange, as well as a framework for the scientific support of the student's work, which ensures the transfer of knowledge in both directions.
Language of teaching:	English
Prerequisites:	None
Preparation/literature:	None
Further information:	

Courses of the module				
Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching form**	**Examination method(s), scope and duration**
Theory-Practice-Project 2, 3: Academic Project Consulting	Professors of the program	1,5	Acad. Consulting (max 5 students per unit)	Project work (PA)

2.6 and 3.6 NON-TECHNICAL ELECTIVE 1 – 2

Module leader:	Prof. Dr. Friedrich Fleischmann		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Placeholder for non-technical electives	**Contact hours (h):**	56h
Scope und frequency of teaching:	14 classes in the 2. or 3. semester of the four-semester program 14 classes in the 1. or 2. semester of the three-semester program	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			
For this placeholder module, students are to select a specific module from the "Non-technical Electives" catalogue.			
Learning outcomes: After completion of the selected non-technical elective module, students have extended and deepened their knowledge and understanding in the respective field. They are able to apply their knowledge and problem-solving skills in complex contexts within the scope of the specific module topic. For detailed learning outcomes please see the module descriptions of each elective module.			
Course content: For course contents please see the module descriptions of each elective module.			
Language of teaching:			
Learning and teaching methods:	See respective elective		
Prerequisites:	None		
Preparation/literature:	See respective elective		
Further information:			

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Non-technical Elective 1/2 (container module)	See respective elective	2	See respective elective	See respective elective
Non-technical Elective 1/2 (container module)	See respective elective	2	See respective elective	

TECHNICAL ELECTIVES

2.7 MICROSYSTEMS AND TRANSDUCERS

Module leader:	Prof. Dr. rer.nat. Ludger Kempen		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☒ Development and Fabrication of Intelligent Systems ☐ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in winter term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

This module provides physical background as well as working principles and modern design of microsensors and microsystems. Results of actual research papers are discussed in a seminar. Students gain first experience in designing elementary microsystems. After completion of the module students are able to …

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- … understand the physical background of different microsensors and -systems;
- … describe the working principle of typical microsensors and -systems;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- … implement the physical transducer principle into a microsensor concept;
- … calculate the sensitivity of microsensors;
- … assess the advantages and disadvantages of different sensor concepts for specific applications;
- … select appropriate materials for different microsystems;
- … configure a microfluidic system;
- … design an elementary microsensor;
- … work with publications from research journals;

Communication and cooperation

- … to illustrate results of actual research in an oral presentation;

Reflection of academic and professional identity

- … reflect their own capability in oral presentation and scientific discussion.

Course content:	- Structure of solids - Mechanical, electrical, magnetic and optical properties of solids - Fundamentals of heat transfer and Diffusion - Transducers for different quantities	- Concepts of different microsensors: Inertial sensors, thermal sensors, pressure and flow sensors, magnetic sensors - Design of integrated systems - Principles of microfluidics - Concepts of microfluidic systems
Language of teaching:	English	
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion, oral presentation Laboratory: Design study of Microsystems	
Prerequisites:	None	
Preparation/literature:	- W. Lang, Sensors and Measurement Systems, River Publisher 2021 - Werner Karl Schomburg: Introduction to Microsystem Design, Springer 2015 - Patrick Tabelling: Introduction to Microfluidics, Oxford 2010	
Further information:		

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Microsystems and Transducers	Ludger Kempen	3	Seminar (S)	Portfolio (PF)
Microsystems and Transducers	Ludger Kempen	1	Laboratory (L)	

2.8 MEASUREMENT AND INSTRUMENTATION

Module leader:	Prof. Dr.-Ing. Friedrich Fleischmann		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☐ Development and Fabrication of Intelligent Systems ☒ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in winter term
Type of module and position in other study programs or continuing education offers:		Elective module in EMSS M.Sc., ENTEC M.Eng., KSS M.Sc.	

Learning outcomes:

After completion of the module, students are able to...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... distinguish between different classes of sensors,
- ... are aware of the impact of mathematical basics of probability theory,
- ... know principles of design of experiments,
- ... are able to use NIST-GUM,

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... apply statistical methods to evaluate significance of measurement results,
- ... assess decisive characteristics of acquisition hardware,
- ... develop signal conditioning HW/SW,
- ... apply systemic thinking in systems design including aspects of EMI control,
- ... design meaningful experiments,

Communication and cooperation

- ... do project work in a team,
- ... decide autonomous about organization and conduct of experiments,
- ... present progress and results to supervisors and peers,
- ... assess results from experiment, evaluate in team and document scientifically,

Reflection of academic and professional identity

- ... reflect system design and test setup with regard to alternative designs,
- ... adhere to standards of professional action and documentation.

Course content:	▪ ANOVA, MANOVA, Hypothesis testing ▪ Uncertainty in measurement ▪ Design of experiments ▪ EMC/EMI in measurement applications	▪ Interfaces and bus systems ▪ Sensor signal conditioning ▪ Examples of electrical measurement of non-electrical properties
Learning and teaching methods:	Seminar: Seminar talk and discussion Laboratory: Project like experimental lab work	
Language of teaching:	English	
Prerequisites:	None	
Preparation/literature:	▪ Palanisamy, S. et al.: Basic Electrical and Instrumentation Engineering Wiley 2021. ▪ Papoulis, S. U. Pillai: Probability, Random Variables, and Stochastic Processes, Mc-Graw-Hill, 4 th ed. ▪ H.-R. Tränkler, L. Reindl (Hrsg.): Sensortechnik, Springer 2015 ▪ Issam Abu-Mahfouz: Instrumentation: Theory and Practice, Part 1 and 2, Springer 2022 Additional papers to be handed out according to seminar topics and researched by stu-dents	
Further information:		

Courses of the module				
Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching form**	**Examination method(s), scope and duration**
Measurement and Instrumentation	Friedrich Fleischmann	2	Seminar (S)	Portfolio (PF)
Measurement and Instrumentation	Friedrich Fleischmann	2	Laboratory (L)	

2.9 STATISTICAL SIGNAL PROCESSING

<table>
<tr><td>Module leader:</td><td colspan="3">Prof. Dr.-Ing. Benjamin Lehmann</td></tr>
<tr><td>ECTS points:</td><td>6 ECTS</td><td>Workload (h):</td><td>180h</td></tr>
<tr><td rowspan="2">Type of module and position in the program:</td><td rowspan="2">Dual and non-dual program:
Technical elective module</td><td>Contact hours (h):</td><td>56h</td></tr>
<tr><td>Self-study (h):</td><td>124h</td></tr>
<tr><td>Profile Allocation:</td><td>☒ Development and Fabrication of Intelligent Systems
☒ Application of Intelligent Systems</td><td>Scope and frequency of teaching:</td><td>14 classes
in winter term</td></tr>
<tr><td colspan="3">Type of module and position in other study programs or continuing education offers:</td><td>/</td></tr>
<tr><td colspan="4">Learning outcomes:
This module conveys an in-depth knowledge and understanding about the basic principles of probability theory, stochastic processes, signal detection and parameter estimation as required for applications in communication, control, imaging systems as well as radar and sonar signal processing. After completion of this module the students are able to ...
Knowledge and understanding (extension, consolidation and understanding of knowledge)
▪ ... understand the concepts of probability theory and stochastic processes;
▪ ... distinguish between different non-stationary and stationary processes;
▪ ... know the principles of hypothesis testing
▪ ... understand common parameter estimation techniques
Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)
▪ ... determine and interpret moments of random variables and moment functions of stochastic processes;
▪ ... select suitable stochastic processes for modeling physical measurements, communication signals, etc.;
▪ ... extent the system theoretic concepts for deterministic input and output signals to stationary stochastic input and output processes;
▪ ... represent and investigate stationary stochastic processes in the frequency domain;
▪ ... set up a hypothesis testing for an appropriate signal detection given different noise processes;
▪ ... apply parameter estimation techniques;
▪ ... name the basic aspects involved in Kalman filtering;
▪ ... investigate and assess the aforementioned topics using MATLAB/ PYTHON;
Communication and cooperation
▪ ... do project work in an international team;
▪ ... present progress and results to supervisors and peers;
▪ ... assess results from experiment, evaluate in team and document scientifically;
Reflection of academic and professional identity
▪ ... reflect system design and test setup with regard to alternative designs;
▪ ... adhere to standards of professional action and documentation.</td></tr>
<tr><td>Course content:</td><td colspan="3">▪ Probability Theory: Random Variables, Distribution Functions, Expectation Operator, Vector-valued Random Variables, Transformations of Random Variables, Convergence Concepts, Laws of Large Numbers, Central Limit Theorems
▪ Stochastic Processes: Fundamentals, Some Particular Processes, Stationary Processes, Stochastic Limiting Operations, Spectral Analysis of Stationary Processes, Systems with Stochastic Inputs, Special Discrete Time Parameter Models
▪ Signal Detection: Neyman-Pearson Hypothesis Testing, Bayes Hypothesis Testing, Bayesian Approach, Maximum Likelihood Ratio Test, Non Parametric Tests
▪ Parameter Estimation: Sufficient Statistic, Linear Least Squares Estimation, Confidence Intervals, Maximum Likelihood Estimation, Bayesian Estimation
▪ Recursive estimation of stochastic processes: Kalman filtering</td></tr>
<tr><td>Language of teaching:</td><td colspan="3">English</td></tr>
<tr><td>Learning and teaching methods:</td><td colspan="3">Seminar: Seminaristic teaching and discussion
Laboratory: Exercises and projects</td></tr>
<tr><td>Prerequisites:</td><td colspan="3">None</td></tr>
<tr><td>Preparation/literature:</td><td colspan="3">▪ B. Lehmann, Statistical Inference in Signals Processing and Machine Learning, lecture</td></tr>
</table>

	notes, HS Bremen ▪ E. Hänsler, *Statistische Signale: Grundlagen und Anwendungen*, Springer, 2001 ▪ A. Papoulis, S.U. Pillai, Probability, Random Variables and Stochastic Processes, Mc-Graw-Hill, 2001 ▪ S. Kay, *Intuitive Probability and Random Processes using MATLAB*, Springer, 2006 ▪ T. Hastie, R. Tibshirani, J. Friedman, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, Springer, 2009 ▪ G. James, D. Witten, T. Hastie, R. Tibshirani, J. Taylor, *An Introduction to Statistical Learning with Applications in Python*, Springer, 2023
Further information:	

Courses of the module

Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching form**	**Examination method(s), scope and duration**
Statistical Signal Processing	Benjamin Lehmann	2	Seminar (S)	Lab-integrating written (90 mins) or oral (30 mins) examination (IP)
Statistical Signal Processing	Benjamin Lehmann	2	Laboratory (L)	

2.10 DESIGN AND REALIZATION OF MIXED-TECHNOLOGY SYSTEMS

Module leader:	Prof. Dr.-Ing. Mirco Meiners		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☒ Development and Fabrication of Intelligent Systems ☒ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in winter term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

The objective of this module is an open-ended project course for self-driven students interested in exploring mixed-technology systems using open-source and selected professional software tools. After completion of this module students ...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... have worked in project teams to generate a database that can (potentially) be sent out for fabrication,
- ... have become familiar with mixed-technology system design;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... are able to develop concepts and to analyze, design and simulate mixed-technology systems,
- ... are able to use integrated design environments for circuit and system design with modern technology;

Communication and cooperation

- ... do system development and design in a team,
- ... decide autonomous about organization and conduct of design steps,
- ... present progress and results to supervisors and peers,
- ... assess results from experiments, evaluate and analyze in a team and document scientifically;

Reflection of academic and professional identity

- ... reflect system design and test setup with regard to alternative designs,
- ... adhere to standards of professional action and documentation.

Course content:	▪ Analyzing and simulating mixed-technology systems over all physical domains, ▪ Design mixed-technology-systems on printed-circuit board (PCB) and integrated-circuit (IC) level, ▪ Interfacing and aggregating mixed-technology systems.
Language of teaching:	English
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion Laboratory: Experimental lab work, design project
Prerequisites:	None, recommended: Microelectronic Circuit Design, Signal Processing
Preparation/literature:	▪ Pavan et. al., Understanding Delta-Sigma Converters, 2017 ▪ Williams and Taylor, Electronic Filter Design Handbook, 2006 ▪ Fraden, Handbook of Modern Sensors, 2016 ▪ Additional papers to be handed out according to design topic
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Design and Realization of Mixed-Technology Systems	Mirco Meiners	2	Seminar (S)	Project Work (PA)
Design and Realization of Mixed-Technology Systems	Mirco Meiners	2	Laboratory (L)	

2.11 TECHNICAL OPTICS

Module leader:	Prof. Dr. rer.nat. Thomas Henning		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☒ Development and Fabrication of Intelligent Systems ☐ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in winter term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

This module conveys systematic skills to design and apply optical systems. After completion of the module students are able to ...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... distinguish between different types of optical systems in fields of medicine, metrology and material processing;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... determine optical beam shaping systems for specific applications;
- ... integrate components into a laser system;
- ... evaluate quality of an optical system with respect to a given application;
- ... design optical beam shaping systems for adjusting laser radiation to a specific application.

Communication and cooperation

- ... do project work in an international team of engineers with different scientific background (Optics, Electronics, Materials, Communications, Metrology);

Reflection of academic and professional identity

- ... .

Course content:	- Typical working principles of optical and photonic systems - Construction of rays passing through an optical system - Characterization of optical systems - Numerical beam propagation with Python	- Development of beam delivery and beam shaping systems - Application of geometrical and wave optical principles for system design - Optical metrology and spectroscopy - Fourier optics
Language of teaching:	English	
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion Laboratory: Experimental lab work	
Prerequisites:	None	
Preparation/literature:	- Goodman, Introduction to Fourier Optics, McGraw Hill - ADAMS, HUGES, Optics f2f, 1rst Ed., Oxford Univ. Press - MALACARA, THOMPSON; Handbook of Optical Engineering; Dekker	
Further information:		

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Technical Optics	Thomas Henning	2	Seminar (S)	Portfolio (PF)
Technical Optics	Thomas Henning	2	Laboratory (L)	

2.12 NUMERICAL METHODS

Module leader:	Dr. David Hilbig		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☒ Development and Fabrication of Intelligent Systems ☒ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in winter term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

This module covers various more advanced topics of numerical programming using a multi-paradigm programming language such as Python. It provides the student with a wide ranging toolset for numerical tasks in data analysis, signal processing, modelling and simulation. These are the backbone of numerous applications in the areas of data sciences, machine learning, financial calculations, computer graphics and engineering. One focus will be set on the efficient implementation of numerical algorithm in vectorized form. It further includes topics of integration, optimization and solving systems of equations.

The module follows a hands-on approach in which newly learned content will be directly implemented in code and tested using various examples for a deeper understanding of the topic. Implementation and testing are carried out in a dedicated work environment on the students' own computer.

After completion of the module the students are able to ...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... transfer numerical tasks into efficient vectorized code;
- ... name and to distinguish between different numerical methods in data analysis;
- ... consider the impact of numerical approximations and limited machine precision in computations;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... develop and program algorithms for numerical data analysis;
- ... create suitable numerical models based on a given problem;
- ... build and execute numerical simulations;
- ... work efficiently with Python tools and packages related to numerical programming;

Communication and cooperation

- ... work more efficiently in a team of multi-cultural and international members
- ... divide workload between members of a team

Reflection of academic and professional identity

- ... pursue a critical assessment of results provided by prebuild numerical solutions.

Course content:	▪ Basics of numerical programming and vectorized calculation ▪ Numerical Integration & Differentiation	▪ Solving LSE & non-linear SE ▪ Interpolation ▪ Optimization ▪ Discrete Fourier Transform & Convolution
Language of teaching:	English	
Learning and teaching methods:	Seminar: Seminaristic teaching, discussion, coding sessions Laboratory: Experimental lab work	
Prerequisites:	None	
Preparation/literature:	▪ Cristian Hill, Learning Scientific Programming with Python Cambridge ▪ Sandeep Nagar, Introduction to Python for Engineers and Scientists, Apress ▪ José Unpingco, Python for Signal Processing, Springer	
Further information:		

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Numerical Methods	David Hilbig	2	Seminar (S)	Portfolio (PF)
Numerical Methods	David Hilbig	2	Laboratory (L)	

2.13 INTRODUCTION TO SYSTEMS ENGINEERING

Module leader:	Prof. Dr.-Ing. Benjamin Lehmann		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☐ Development and Fabrication of Intelligent Systems ☒ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in winter term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

This introductory course offers a comprehensive overview of systems engineering, emphasizing the interdisciplinary nature of the field. The fundamental processes involved in the design, integration and management of complex systems over their life cycles is addressed. The course covers essential topics such as systems thinking, requirements engineering, modeling and simulation, risk management and system verification and validation. After completion of this module the students are able to ...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... be aware of the key principles and processes of systems engineering;
- ... describe how systems engineering principles are applied in a variety of industries;
- ... name principles of model-based systems engineering;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... apply systemic thinking to complex problem-solving scenarios;
- ... gain proficiency in requirements engineering, analysis, and management;
- ... asses system modeling and simulation techniques in order to shorten engineering time and budget;
- ... reflect system design and test setup with regard to alternative designs;
- ... evaluate and manage risks and ensure quality in system development;
- ... apply engineering project management to complex development tasks;
- ... participate in the verification and validation of emergent systems;
- ... develop practical skills through case studies and group projects;

Communication and cooperation

- ... do project work in an international team;
- ... present progress and results to supervisors and peers;
- ... assess results from experiment, evaluate in team and document scientifically;

Reflection of academic and professional identity

- ... reflect system design and analyze implications before a system development starts;
- ... adhere to standards of professional action and documentation.

Course content:	▪ Systems Thinking and Complexity ▪ Systems Life Cycle and Engineering Processes ▪ Requirement Engineering ▪ System Architecture and Design ▪ Modeling and Simulation ▪ Risk Management in SE	▪ Systems Integration and Interface Management ▪ Verification, Validation, and Testing ▪ Quality Assurance and Continuous Improvement ▪ Systems Engineering Management and Leadership
Language of teaching:	English	
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion Laboratory: Experimental lab work	
Prerequisites:	None	
Preparation/literature:	▪ B. Lehmann, Introduction to Systems Engineering, lecture notes, Hochschule Bremen ▪ A. Kossiakoff, W. Sweet, S. Seymour, S. Bieme, Systems Engineering Principles and Practice, 2020 ▪ INCOSE, Systems Engineering Handbook, Wiley, 2023 ▪ D. Dori, Model-Based Systems Engineering with OPM and SysML, Springer, 2016	
Further information:		

Courses of the module				
Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching form**	**Examination method(s), scope and duration**
Introduction to Systems Engineering	Benjamin Lehmann	2	Seminar (S)	Lab-integrating written (90 mins) or oral (30 mins) examination (IP)
Introduction to Systems Engineering	Benjamin Lehmann	2	Laboratory (L)	

2.14 FUNDAMENTALS OF MACHINE LEARNING

<table>
<tr><td>Module leader:</td><td colspan="3">Prof. Dr.-Ing. Mario Goldenbaum</td></tr>
<tr><td>ECTS points:</td><td>6 ECTS</td><td>Workload (h):</td><td>180h</td></tr>
<tr><td rowspan="2">Type of module and position in the program:</td><td rowspan="2">Dual and non-dual program:
Technical elective module</td><td>Contact hours (h):</td><td>56h</td></tr>
<tr><td>Self-study (h):</td><td>124h</td></tr>
<tr><td>Profile Allocation:</td><td>☒ Development and Fabrication of Intelligent Systems
☒ Application of Intelligent Systems</td><td>Scope and frequency of teaching:</td><td>14 classes
in winter term</td></tr>
<tr><td colspan="3">Type of module and position in other study programs or continuing education offers:</td><td>/</td></tr>
</table>

Learning outcomes:

The goal of this module is to provide a rigorous introduction to the main concepts underlying machine learning as well as to present the theoretical basis and conceptual tools needed for the discussion and justification of learning algorithms. After successful completion of this module the students are able to...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... rigorously answer the question of "What is learning?";
- ... understand the main models and assumptions of statistical learning theory;
- ... show "how a machine can learn" by describing the ERM, SRM, and MDL learning paradigms;
- ... quantify the amount of data needed to learn a given concept;
- ... understand how and why learning might fail and that there is "no free lunch";

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... use learning theory to mathematically analyze learning tasks;
- ... consider the bias-complexity tradeoff when choosing hypothesis classes, loss functions, and algorithms;
- ... evaluate the performance of a learned model and to apply model selection;
- ... develop a strategy on what to do if the learning process failed;

Communication and cooperation

- ... work effectively in an international team on machine learning problems;
- ... present concepts, progress, and results to supervisors and peers;
- ... assess results from experiments, evaluate in a team, and document scientifically;

Reflection of academic and professional identity

- ... reflect ideas critically and solution-oriented as essence of engineering thinking;
- ... adhere to standards of professional action and documentation.

<table>
<tr><td>Course content:</td><td>▪ PAC and agnostic PAC learning models
▪ Learning via uniform convergence
▪ Concentration-of-measure inequalities
▪ Bias-complexity tradeoff
▪ Vapnik-Chervonenkis dimension</td><td>▪ Nonuniform learning
▪ Model selection and validation
▪ Regularization
▪ Elementary algorithms (e.g., linear predictors, boosting, stochastic gradient descent, SVMs)</td></tr>
<tr><td>Language of teaching:</td><td colspan="2">English</td></tr>
<tr><td>Learning and teaching methods:</td><td colspan="2">Seminar: Seminaristic teaching and discussion
Laboratory: Exercises and assignments</td></tr>
<tr><td>Prerequisites:</td><td colspan="2">None</td></tr>
<tr><td>Preparation/literature:</td><td colspan="2">▪ M. Goldenbaum: Fundamentals of Machine Learning, lecture notes, HS Bremen
▪ S. Shalev-Schwartz, S. Ben-David (2014): Understanding Machine Learning – From Theory to Algorithms, Cambridge University Press
▪ M. Mohri, A. Rostamizadeh, and A. Talwalkar (2018), Foundations of Machine Learning, 2nd ed., MIT Press
▪ V. N. Vapnik (2000): The Nature of Statistical Learning Theory, 2nd ed., Springer
▪ B. Schölkopf, A. J. Smola (2002): Learning with Kernels – Support Vector Machines, Regularization, Optimization, and Beyond, MIT Press</td></tr>
<tr><td>Further information:</td><td colspan="2"></td></tr>
</table>

Courses of the module				
Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching form**	**Examination method(s), scope and duration**
Fundamentals of Machine Learning	Mario Goldenbaum	2	Seminar (S)	Lab-integrating written (90 mins) or oral (30 mins) examination (IP)
Fundamentals of Machine Learning	Mario Goldenbaum	2	Laboratory (L)	

2.15 HARDWARE IMPLEMENTATION OF AI

Module leader:	N.N.		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☒ Development and Fabrication of Intelligent Systems ☒ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in winter term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

This module provides comprehensive knowledge and practical skills in designing hardware architectures for Artifical Intelligence (AI) algorithms, focusing on efficiency, performance, and application-specific optimization. After completion of this module, the students are able to:

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... explain and critically evaluate various AI hardware architectures, including GPUs, TPUs, FPGAs, and neuromorphic chips,
- ... describe the specific hardware requirements of AI algorithms and their implications for system design.

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... design and optimize hardware architectures for AI accelerators, considering energy efficiency, performance, and reliability,
- ... apply algorithm-hardware co-design methodologies to create more efficient AI systems,
- ... utilize software tools and frameworks for AI hardware design and simulation,
- ... develop application-specific AI hardware solutions for diverse domains.

Communication and cooperation

- **...** articulate complex ideas and design decisions related to AI hardware architectures in both written and oral forms,
- ... collaborate effectively in interdisciplinary teams to solve AI hardware design challenges.

Reflection of academic and professional identity

- ...critically evaluate the ethical implications and societal impact of AI hardware design choices,
- ... develop a professional identity as an AI hardware designer, understanding the field's rapid evolution and the need for continuous learning and adaptation.

Course content:	- Fundamentals of AI hardware architectures (GPUs, TPUs, FPGAs, and neuromorphic chips, memory architectures for AI workloads) - Algorithm-hardware Co-design (optimization of AI algorithms considering hardware constraints, hardware design exploration) - Energy efficiency and performance optimization (techniques for reducing power consumption, acceleration of matrix operations) - Security and reliability (hardware-based security mechanisms for AI, fault tolerance and robustness) - Software tools and frameworks (overview of available tools, practical application of selected tools) - Application-specific optimization (case studies from various domains, design of AI hardware for specific application scenarios)
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion Laboratory: Experimental lab work
Prerequisites:	Basic knowledge of digital circuit design, computer architecture, and machine learning
Preparation/literature:	- Liu, A. C. C., & Law, O. M. K. (2021). Artificial Intelligence Hardware Design: Challenges and Solutions. Wiley-IEEE Press. - Tahoori, M. B. et al. (2024). EDAI: German Open-Source Tools for AI Algorithm-Hardware Co-Design. Karlsruhe Institute of Technology (KIT).

	▪ Gillich, S. (2023). Hardware acceleration for AI applications. Intel Deutschland. ▪ Hennessy, J. L., & Patterson, D. A. (2022). Computer Architecture: A Quantitative Approach (7th ed.). Morgan Kaufmann. ▪ Chen, Y. H., Krishna, T., Emer, J. S., & Sze, V. (2017). Eyeriss: An energy-efficient reconfigurable accelerator for deep convolutional neural networks. IEEE Journal of Solid-State Circuits, 52(1), 127-138. ▪ Sze, V., Chen, Y. H., Yang, T. J., & Emer, J. S. (2017). Efficient processing of deep neural networks: A tutorial and survey. Proceedings of the IEEE, 105(12), 2295-2329 ▪ Jouppi, N. P., Young, C., Patil, N., & Patterson, D. (2018). A domain-specific architecture for deep neural networks. Communications of the ACM, 61(9), 50-59
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Hardware Implementation of AI	N.N.	2	Seminar (S)	Written (90 mins) or oral (30 mins) examination and non-graded course-work (KL or MP + SL)
Hardware Implementation of AI	N.N.	2	Laboratory (L)	

2.16 SATELLITE COMMUNICATION

Module leader:	Prof. Dr. Sören Peik		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☐ Development and Fabrication of Intelligent Systems ☒ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in winter term
Type of module and position in other study programs or continuing education offers:		Elective Module in AT M.Sc. and EMSS M.Sc.	

Learning outcomes:

The module provides a comprehensive introduction to satellite communications and a thorough grounding in the design issues of orbit selection, link design, and signal processing. Throughout the term references to and discussions of today's satellite systems are included. After completion of this module the students are able to …

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- … describe the orbital movement of satellites;
- … compute the satellite location in space and with respect to a ground station;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- … evaluate the extraordinary design goals for a space environment;
- … set up a link budget;
- … assess the risks and hazards of space flight;
- … apply engineering project management to space flight applications;

Communication and cooperation

- … do project work in an international team;

Reflection of academic and professional identity

Course content:	▪ Introduction ▪ Orbital Mechanics ▪ Satellite Launch Systems ▪ The Space Segment ▪ The Ground Segment	▪ Space System Project Management ▪ Space System Engineering ▪ The Communication Link ▪ Satellite Based Navigation
Language of teaching:	English	
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion Laboratory: Experimental lab work	
Prerequisites:	None	
Preparation/literature:	▪ Maral, Bousquet, Satellite Communication Systems, Wiley Books ▪ M. Richharia, Satellite Communication Systems and Design Principles, MacMillan ▪ Larson & Wertz, Space Mission Analysis and Design ▪ M. Richharia, Satellite Communication Systems, MacMillan ▪ B. Sklar, Digital Communications, Prentice Hall ▪ W. Mansfeld, Satellitenortung und Navigation, Vieweg	
Further information:		

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Satellite Communications	Sören Peik	2	Seminar (S)	Lab-integrating written (90 mins) or oral (30 mins) examination (IP)
Satellite Communications	Sören Peik	2	Laboratory (L)	

2.17 APPLIED AUTONOMOUS DRIVING

<table>
<tr><td>Module leader:</td><td colspan="3">Prof. Dr.-Ing. Benjamin Lehmann</td></tr>
<tr><td>ECTS points:</td><td>6 ECTS</td><td>Workload (h):</td><td>180h</td></tr>
<tr><td rowspan="2">Type of module and position in the program:</td><td rowspan="2">Dual and non-dual program:
Technical elective module</td><td>Contact hours (h):</td><td>56h</td></tr>
<tr><td>Self-study (h):</td><td>124h</td></tr>
<tr><td>Profile Allocation:</td><td>☐ Development and Fabrication of Intelligent Systems
☒ Application of Intelligent Systems</td><td>Scope and frequency of teaching:</td><td>14 classes
in winter term</td></tr>
<tr><td colspan="2">Type of module and position in other study programs or continuing education offers:</td><td colspan="2">Elective Module in EMSS M.Sc.</td></tr>
<tr><td colspan="4">Learning outcomes:
This module conveys an in-depth introduction in applied autonomous driving, focusing on both fundamental concepts and emerging technologies. While self-driving cars are a key area of study, the course also explores the principles behind all types of unmanned vehicles. After successful completion of this module the students will be able to...
Knowledge and understanding (extension, consolidation and understanding of knowledge)
▪ ... know principles of sensors, control systems, and basic machine learning techniques that enable autonomous operations;
▪ ... use the gained knowledge to further explore and innovate in the field of autonomous vehicles across different industries;
▪ ... develop an understanding of the capabilities and limitations of current approaches;
Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)
▪ ... explain and recognize the main components of self-driving vehicles;
▪ ... distinguish the sensor solutions for self-driving cars and adopt the best one for a given scenario;
▪ ... evaluate the performance of a motion control system;
▪ ... asses the methods used for environment perception;
▪ ... simulate and analyse unmanned vehicles using the framework MATLAB;
Communication and cooperation
▪ ... do project work in an international team;
▪ ... present progress and results to supervisors and peers;
▪ ... assess results from experiment, evaluate in team and document scientifically;
Reflection of academic and professional identity
▪ ... reflect system design and test setup with regard to alternative designs;
▪ ... adhere to standards of professional action and documentation.</td></tr>
<tr><td>Course content:</td><td>▪ Environment Perception
▪ Moving, Braking, Steering
▪ Communication
▪ Motion and Odometry
▪ Local Navigation</td><td colspan="2">▪ Localization
▪ Sensor Fusion
▪ Motion Planning
▪ Testing and Simulation of Autonomous Vehicles
▪ Regulations and Standards</td></tr>
<tr><td>Language of teaching:</td><td colspan="3">English</td></tr>
<tr><td>Learning and teaching methods:</td><td colspan="3">Seminar: Seminaristic teaching and discussion
Laboratory: Complex projects</td></tr>
<tr><td>Prerequisites:</td><td colspan="3">None</td></tr>
<tr><td>Preparation/literature:</td><td colspan="3">▪ B. Lehmann, Applied Autonomous Driving, lecture notes, Hochschule Bremen
▪ M. Maurer, J. Gerdes, B. Lenz, H. Winner, Autonomous driving, Springer, 2016
▪ M. Ben-Ari, F. Mondada, Elements of robotics, Springer, 2018
▪ R. Fan, S. Guo, M. Bocus, Autonomous Driving Perception: Fundamentals and Applications, Springer, 2023
▪ X. Zhang , J. Zhiwei Li, H. Liu, M. Zhou, L. Wang, Z. Zou, Multi-sensor Fusion for Autonomous Driving, Springer, 2023</td></tr>
<tr><td>Further information:</td><td colspan="3"></td></tr>
</table>

Courses of the module				
Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching form**	**Examination method(s), scope and duration**
Applied Autonomous Driving	Benjamin Lehmann	2	Seminar (S)	Lab-integrating written (90 mins) or oral (30 mins) examination (IP)
Applied Autonomous Driving	Benjamin Lehmann	2	Laboratory (L)	

2.18 SELECTED TOPICS OF ELECTRONICS ENGINEERING 1

Module leader:	Prof. Dr.-Ing. Friedrich Fleischmann		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	(☒) Development and Fabrication of Intelligent Systems (☒) Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in winter term
Type of module and position in other study programs or continuing education offers:		Elective module in EMSS M.Sc., ENTEC M.Eng., KSS M.Sc.	

Learning outcomes:

After completion of the module, students are able to…

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- … understand and explain current research-, application- or technology-oriented concepts, methods and tools in a specific field of electronics engineering;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- … assess concepts, methods and tools and select most appropriate ones for specific task;
- … apply those methods and tools to solve a specific task;
- … design, implement and document scientifically solution;
- … evaluate and discuss solution;

Communication and cooperation

- … do project work in a small team;
- … decide autonomous about organization and conduct of experiments;
- … present progress and results to supervisors and peers;
- … assess results from experiment, evaluate in team and document scientifically;

Reflection of academic and professional identity

- … reflect system design and test setup with regard to alternative designs;
- … adhere to standards of professional action and documentation.

Course content:	Depending on the topic, students are introduced to at least one current topic from research and/or practice in electronics engineering. Conceptual issues are discussed, methodological knowledge is imparted and what has been learned is applied to practical work. Examples of possible topics are ▪ Design of hardware for intelligent systems ▪ Artificial Intelligence for autonomous vehicles ▪ Design of automation systems ▪ Environmental research by remote sensing ▪ Greenhouse gas monitoring
Learning and teaching methods:	*Seminar:* Seminaristic teaching, discussion, coding sessions *Laboratory:* Project like experimental lab work
Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester
Further information:	Additional teaching and supportive material are available via aulis tool

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Selected Topics of Electronics Engineering 1	Teaching staff of MScEE or external lecturers	2	Seminar (S)	Lab-integrating written (90 mins) or oral (30 mins) examination (IP)
Selected Topics of Electronics Engineering 1		2	Laboratory (L)	

2.19 ELECTRONICS ENGINEERING PROJECT 1

Module leader:	Prof. Dr. Friedrich Fleischmann		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Non-dual program only: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	Depending on the specific project chosen	**Scope and frequency of teaching:**	14 classes in winter term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

After successful completion of this module the students are able to …

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- … identify and describe relevant project parameters like key engineering components, design tools and measurement equipment;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- … evaluate and structure a given project topic on EE regarding scheduling, monitoring and control;
- … do self-directed studies within running research projects on electronics engineering under guidance of project manager;
- … acquire knowledge and skills on given engineering topics by applying "learning by doing"

Communication and cooperation

- … work effectively in a team;
- … present scientific results on investigations, design and measurements
- … improve the outcome of group meetings and discussions;

Reflection of academic and professional identity

- … reflect system design and test setup with regard to alternative designs,
- … adhere to standards of professional action and documentation.

Course content:	▪ Introduction to EEP: Subjects are related to the Electronics Engineering program and are usually inspired by current research projects in institutes i3m, IWSS and IAT ▪ Methods on scientific investigations in electronics engineering using literature and internet support ▪ Team work ▪ Project implementation, scheduling, monitoring and control ▪ Function, performance and application of project relevant engineering components, design tools and measurement equipment within a defined research project on optics, electronics, microsystems, communications, measurement and instrumentation ▪ Methods on evaluation of results, documentation and presentation techniques
Language of teaching:	English
Learning and teaching methods:	Project work
Prerequisites:	None
Preparation/literature:	References are announced at the beginning of the project.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Electronics Engineering Project 1	Professors of the program depending on project chosen	4	Project (P)	Project Work (PA)

3.7 ADVANCED HARDWARE VERIFICATION

Module leader:	Prof. Dr.-Ing. Stefan Wolter		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☒ Development and Fabrication of Intelligent Systems ☐ Application	**Scope and frequency of teaching:**	14 classes in summer term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

Driven by the evolution of the semiconductor process technology, verification of digital chip designs become more difficult and more complex. To address this, the module covers high-level verification techniques. The module focuses on Functional Verification using SystemVerilog applying the IEEE-1800 standard. After successful completion of this module students are able to develop SystemVerilog testbenches applying the concepts of coverage-driven verification, assertions and constraint-random test generation. After completion of this module, the students are able to:

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... know different verification techniques,
- ... understand basic verification concepts,
- ... consolidate knowledge in the field of digital hardware.

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... design class-based testbenches with SystemVerilog,
- ... write SystemVerilog assertions, and bind them to design objects,
- ... create directed and constraint-random tests,
- ... develop a functional coverage model,
- ... simulate testbenches with Questa and evaluate the results.

Communication and cooperation

- ... discuss with design engineers to understand mistakes in the interpretation of the design specification,
- ... present progress and results to supervisors and peers,
- ... assess results from simulation, evaluate in team and document scientifically.

Reflection of academic and professional identity

- ... adhere to standards of professional action and documentation.

Course content:	▪ Introduction to the state of the art ▪ SystemVerilog Language Basics ▪ SystemVerilog Assertions ▪ SystemVerilog classes, parallel blocks, interprocess communication/thread control ▪ Constrained Randomization ▪ Functional Coverage ▪ Introduction into UVM ▪ Working with Questa tools
Language of teaching:	English
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion Laboratory: Experimental lab work
Prerequisites:	None
Preparation/literature:	▪ IEEE Std. 1800-2023, IEEE standard for SystemVerilog – Unified Hardware Design, Specification, and Verification Language ▪ C. Spear and G. Tumbush, SystemVerilog for Verification, Springer ▪ Cerny/Dudani/Havlicek/Korechmny, The Power of Assertions in SystemVerilog, Springer ▪ Ashok B. Mehta, SystemVerilog Assertions and Functional Coverage, Springer ▪ Kathleen A. Made and Sharon Rosenberg, A Practical Guide to Adopting the Univer-

	sal Verification Methodology (UVM), Cadence Design Systems
Further information:	

Courses of the module				
Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching form**	**Examination method(s), scope and duration**
Advanced Hardware Verification	Stefan Wolter	2	Seminar (S)	Written (90 mins) or oral (30 mins) examination and non-graded coursework (KL or MP + SL)
Advanced Hardware Verification	Stefan Wolter	2	Laboratory (L)	

3.8 COMPUTER AIDED DATA ACQUISITION

Module leader:	Prof. Dr.-Ing. Friedrich Fleischmann		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☒ Development and Fabrication of Intelligent Systems ☒ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in summer term
Type of module and position in other study programs or continuing education offers:		Elective module in EMSS M.Sc., ENTEC M.Eng., KSS M.Sc.	

Learning outcomes:
Students learn to design task test circuits and acquisition hardware as well as to use interfaces and instrumentation buses. They will be able to select hardware, bus systems and control language according to the needs of the measuring task. They can design and apply automated test systems, evaluate results and document the setup. After successful completion of this module students are able to...

Knowledge and understanding (extension, consolidation and understanding of knowledge)
- ... distinguish between actual tools in measurement automation regarding overhead, latency, maintainability;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)
- ... assess decisive characteristics of acquisition hardware;
- ... integrate components into a system considering mutual interaction and influence;
- ... apply systemic thinking in systems design including heterogeneous system components and topologies;

Communication and cooperation
- ... do project work in a team;
- ... decide autonomous about organization and conduct of experiments;
- ... present progress and results to supervisors and peers,
- ... assess results from experiment, evaluate in team and document scientifically;

Reflection of academic and professional identity
- ... reflect system design and test setup with regard to alternative designs,
- ... adhere to standards of professional action and documentation.

Course content:	▪ Types and use of acquisition hardware ▪ Interfaces and bus systems ▪ Software tools for automated measurements and signal processing ▪ CADA project: DAQ with uC
Language of teaching:	English
Learning and teaching methods:	Seminar: Seminar talk and discussion Laboratory: Project like experimental lab work
Prerequisites:	None
Preparation/literature:	▪ R. Lerch, Elektrische Messtechnik, Springer ▪ A.V. Oppenheim, R.W. Schafer: Digital Signal Processing, Prentice-Hall ▪ A.V. Oppenheim, Applications of Digital Signal Processing, Prentice-Hall ▪ P. Addison, The illustrated wavelet transform handbook, IOP ▪ R.B. Angus, T.E. Hulbert: VEE Pro: Practical graphical programming, Springer ▪ Agilent VEE - Practical Graphical Programming, Agilent ▪ H. Langtangen: A Primer on Scientific Programming with Python ▪ Additional papers to be handed out according to seminar topics and researched by students
Further information:	

Courses of the module				
Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching form**	**Examination method(s), scope and duration**
Computer Aided Data Acquisition	Friedrich Fleischmann	2	Seminar (S)	Portfolio (PF)
Computer Aided Data Acquisition	Friedrich Fleischmann	2	Laboratory (L)	

3.9 INFORMATION AND CODING THEORY

Module leader:	Prof. Dr.-Ing. Mario Goldenbaum		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):** **Self-study (h):**	56h 124h
Profile Allocation:	☐ Development and Fabrication of Intelligent Systems ☒ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in summer term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

The goal of this module is to introduce the basic concepts, mathematical tools, and main results of information theory as well as the very basics of algebraic coding theory. The methods are then used to study the fundamental limits of single-user data compression and data transmission. After successful completion this module the students are able to...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... describe and quantify information;
- ... explain each component of Shannon's (statistical) point-to-point communication model;
- ... know the fundamental limits of data compression and data transmission;
- ... understand how these fundamental limits can be achieved;
- ... know basic coding schemes and how they are used in modern digital communication systems;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... use information theory to mathematically analyze elementary data sources and transmission channels;
- ... assess whether given system requirements can be achieved by any choice of codes;
- ... develop practical coding schemes;
- ... evaluate the performance of source and channel codes;

Communication and cooperation

- ... work effectively in an international team on data compression and data transmission problems;
- ... present concepts, progress, and results to supervisors and peers;
- ... assess results from experiments, evaluate in a team, and document scientifically;

Reflection of academic and professional identity

- ... reflect ideas critically and solution-oriented as essence of engineering thinking;
- ... adhere to standards of professional action and documentation.

Course content:	▪ Information measures ▪ Source coding theorem ▪ Channel coding theorem ▪ Source-channel separation ▪ Differential entropy	▪ AWGN channel ▪ Finite fields ▪ Linear block codes ▪ Codes and polynomials ▪ Decoding methods and error bounds
Language of teaching:	English	
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion Laboratory: Exercises and assignments	
Prerequisites:	None	
Preparation/literature:	▪ M. Goldenbaum, *Introduction to Information and Coding Theory*, lecture notes, HS Bremen ▪ T. M. Cover, J. A. Thomas (2006): *Elements of Information Theory*, 2nd ed., John Wiley & Sons ▪ R. G. Gallager (1968): *Information Theory and Reliable Communication*, John Wiley & Sons ▪ R. E. Blahut (2008): *Algebraic Codes for Data Transmission*, Cambridge Univ. Press ▪ S. Lin, D. J. Costello (2004): *Error Control Coding*, Prentice Hall	

Further information:				
Courses of the module				
Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching methods**	**Examination method(s), scope and duration**
Information and Coding Theory	Mario Goldenbaum	2	Seminar (S)	Lab-integrating written (90 mins) or oral (30 mins) examination (IP)
Information and Coding Theory	Mario Goldenbaum	2	Laboratory (L)	

3.10 MICROFABRICATION

Module leader:	Prof. Dr. rer.nat. Ludger Kempen		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☒ Development and Fabrication of Intelligent Systems ☐ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in summer term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

This module provides knowledge about all typical production processes of silicon microtechnology. A simple mechanical sensor or microfluidic system will be produced and characterized by groups of students. After successful completion of this module students are able to...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... describe the typical process flow of microfabrication
- ... understand the physical background of microfabrication processes

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... create a suitable process flow depending on the needs of specific microsystems
- ... reflect the influence of different process parameters on the process outcome
- ... conduct some basic process steps of microfabrication
- ... characterize a produced microsystem and asses the outcome in comparison to the design
- ... document the executed process steps and the evaluation results in scientific report

Communication and cooperation

- ... work effectively in a team

Reflection of academic and professional identity

- ... reflect the impact of microfabrication processes on environment

Course content:	▪ Basic knowledge of cleanroom, vacuum and plasma technology ▪ Process steps of microfabrication including film deposition, lithography, etching, doping, wafer bonding and packaging ▪ Measurement techniques for process control and characterization of microsystems
Language of teaching:	English
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion Laboratory: Experimental lab work
Prerequisites:	None
Preparation/literature:	▪ S. Franssila, Introduction to Microfabrication, Wiley, 2010 ▪ Tilli et.al, Handbook of Silicon based MEMS Materials and Technology, Elsevier 2020
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Microfabrication	Ludger Kempen	2	Seminar (S)	Lab-integrating written (90 mins) or oral (30 mins) examination (IP)
Microfabrication	Ludger Kempen	2	Laboratory (L)	

3.11 FIBER OPTICS

Module leader:	Prof. Dr. rer.nat. Carsten Reinhardt		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):** **Self-study (h):**	56h 124h
Profile Allocation:	☒ Development and Fabrication of Intelligent Systems ☐ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in summer term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

The student can operate optical and electronic measurement equipment in the areas of power, polarization and spectral analysis and is able to understand the interactions of components in a fiber-optic system by systematic test and measurement. After successful completion of this module students are able to...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... select suitable detector types like thermal detectors and photodetectors and to measure quantum efficiency, responsivity, insertion loss and polarization dependent and wavelength dependent loss;
- ... describe and measure state of polarization, degree of polarization, polarization ellipse, Stokes parameter, Poincare sphere, birefringence in crystals, optical activity and state of polarization in optical fibers;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... use wavelength filters, blazed diffraction gratings in transmission and reflection and calculate resolving power;
- ... determine parameters of Fabry-Perot-interferometer like free spectral range, finesse and resolution;
- ... distinguish between Fresnel- and Fraunhofer diffraction and apply diffraction for measurement of diameter and ovality of optical fibers and wires;

Communication and cooperation

- ... do project work in an international team of engineers with different scientific background (Optics, Electronics Transmission, Testing, Networking);

Reflection of academic and professional identity

Course content:	▪ Introduction to fiber optic test and measurement ▪ Optical power measurement ▪ Polarization measurement ▪ Spectral Analysis ▪ Diffraction of Light and Measurement Applications
Language of teaching:	English
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion Laboratory: Experimental lab work
Prerequisites:	None
Preparation/literature:	▪ D. Derickson, Fiber optic Test and Measurement, Prentice Hall ▪ F.L. Pedrotti et al., Introduction to Optics, Prentice Hall ▪ G.P. Agrawal, Fiber-Optic Communication Systems, Wiley Interscience ▪ G. Keiser, Optical Fiber Communications, McGraw-Hill Intern. ▪ W. Daum et al., Polymer Optical Fibers for Data Communication, Springer ▪ E. Voges, K. Petermann, Optische Kommunikationstechnik, Springer
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Fiber Optics	Carsten Reinhardt	2	Seminar (S)	Lab-integrating written

Fiber Optics	Carsten Reinhardt	2	Laboratory (L)	

3.12 MICROWAVE CIRCUITS AND SYSTEMS

Module leader:	Prof. Dr. Sören Peik		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☒ Development and Fabrication of Intelligent Systems ☐ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in summer term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

The aim of this module is to gain an understanding of today's design process of active and passive microwave circuits. Secondly, the module provides an overview of typical microwave circuit applications for modern wireless communication systems. After successful completion of this module students will be able to...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... explain the wave propagation in free space and on lines;
- ... explain the basic operation of microwave systems like receivers, transmitters, radars etc.;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... design simple microwave power divider and coupler;
- ... evaluate the noise performance of microwave systems;
- ... design a low noise microwave amplifier in a team;

Communication and cooperation

- Work effectively in a team;

Course content:	▪ Introduction ▪ Repetition of Wave Theory ▪ Microwave Network Analysis ▪ Impedance Matching and Tuning ▪ Microwave Passive Structures	▪ Noise in Two-Ports ▪ Microwave Amplifier Design ▪ Mixer and Oscillator ▪ Microwave Systems
Language of teaching:	English	
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion Laboratory: Experimental lab work	
Prerequisites:	None	
Preparation/literature:	▪ D. M. Pozar, Microwave and RF Design of Wireless Systems, Addison-Wesley, 2002 ▪ R. Ludwig, P. Bretchko, RF Circuit Design, Prentice Hall, 2000 ▪ R. E. Collin, Foundations For Microwave Engineering, McGraw-Hill, 1992 ▪ G. Gonzalez, Microwave Transistor Amplifiers, Prentice Hall, 1997 ▪ P. Abrie, Design of RF and Microwave Amplifiers and Oscillators, Artech House, 2000 ▪ G. Maral, M. Bousquet, Satellite Communication Systems: Systems, Techniques and Technology, Wiley Books, 1998	
Further information:		

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Microwave Circuits and Systems	Sören Peik	2	Seminar (S)	Lab-integrating written

Microwave Circuits and Systems	Sören Peik	2	Laboratory (L)	(90 mins) or oral (30 mins) examination (IP)

3.13 IMAGE PROCESSING AND PATTERN RECOGNITION

Module leader:	Prof. Dr.-Ing. Benjamin Lehmann		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☐ Development and Fabrication of Intelligent Systems ☒ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in summer term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

The objective of this module is to introduce the basic principles of image processing methods and their discretization, the necessary processing steps for pattern recognition as well as the evaluation of developed algorithms for automatic target recognition systems. All principles are introduced for a wide range of different applications, like 2D-, 3D-, grayscale-, coloured-, multispectral-images or videos. A detailed introduction to neural networks is given with applications in deep learning technics. After successful completion of this module the students will be able to...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... understand the basic concepts of image processing and pattern recognition;
- ... be aware of the different kind of information types involved and how to access them efficiently;
- ... categorize latest development in pattern recognition;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... extent the system theoretic concepts for imaging systems;
- ... specify appropriate filtering/ segmentation and classification approaches for data with uncertainties;
- ... select suitable methods to reduce redundant information and to select appropriate features;
- ... establish an understanding for limitations of different methods depending on the application;
- ... explorer benefits and drawback of deep neural networks;
- ... investigate and assess the aforementioned topics using PYTHON/ MATLAB;

Communication and cooperation

- ... do project work in an international team;
- ... present progress and results to supervisors and peers;
- ... assess results from experiment, evaluate in team and document scientifically;

Reflection of academic and professional identity

- ... reflect system design and test setup with regard to alternative designs;
- ... adhere to standards of professional action and documentation.

Course content:	▪ Image Processing - Introduction to image processing - System theoretic concepts of imaging systems - Pixel and region processing - Detection, segmentation, feature extraction and classification	▪ Pattern Recognition - Introduction to pattern recognition - Feature selection techniques - Classifier concepts - Deep Neural Networks ▪ Automatic target recognition systems ▪ Deep Generative Networks ▪ Explainable AI
Language of teaching:	English	
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion Laboratory: Exercises and projects	

Prerequisites:	None
Preparation/literature:	▪ B. Lehmann, Image Processing and Pattern Recognition, lecture notes, HS Bremen ▪ T. Hastie, et al., The Elements of Statistical Learning: Data Mining, Inference and Prediction, Springer, 2017 ▪ B. Jähne, Digital Image Processing: Concepts, Algorithms and Scientific Applications, Springer, 2005 ▪ C.M. Bishop, Pattern Recognition and Machine Learning, Springer, 2007 ▪ S. Theodoridis et al., Introduction to Pattern Recognition – A MATLAB Approach, Academic Press, 2010 ▪ I. Goodfellow, Y. Bengio, A. Courville, Deep Learning, MIT Press, 2016
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Image Processing and Pattern Recognition	Benjamin Lehmann	2	Seminar (S)	Lab-integrating written (90 mins) or oral (30 mins) examination (IP)
Image Processing and Pattern Recognition	Benjamin Lehmann	2	Laboratory (L)	

3.14 ADVANCED TOPICS OF LASERS

Module leader:	Prof. Dr. rer.nat. Thomas Henning		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☒ Development and Fabrication of Intelligent Systems ☐ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in summer term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

This module conveys systematic skills to design and apply laser systems. After successful completion of this module the students will be able to...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... distinguish between different types of laser systems and typical laser applications in fields of medicine, metrology and material processing;
- ... know principles of laser systems for specific applications;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... apply systemic thinking in integrating of components into a laser system;
- ... evaluate the quality of a laser system with respect to a given application;
- ... design optical beam shaping systems for adjusting laser radiation to a specific application;

Communication and cooperation

- ... do project work in an international team of engineers with different scientific background (Optics, Electronics, Materials, Communications, Metrology);

Reflection of academic and professional identity

- ...;
- ... .

Course content:	- Typical laser applications: laser cleaning, rapid prototyping, medical applications, laser annealing - Characterization of laser radiation - Development of beam delivery and beam shaping systems	- Application of short pulse laser systems - Generation of short pulses - Laser micro processing - Optical metrology and spectroscopy
Language of teaching:	English	
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion Laboratory: Experimental lab work	
Prerequisites:	None	
Preparation/literature:	- A.E. Siegman, Lasers, University Science Book - O. Svelto, Principles of Lasers, Plenum Press - M. Young, Optics and Lasers, Springer	
Further information:		

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Advanced Topics of Lasers	Thomas Henning	2	Seminar (S)	Portfolio (PF)
Advanced Topics of Lasers	Thomas Henning	2	Laboratory (L)	

3.15 UNDERWATER ACOUSTICS AND SONAR SIGNAL PROCESSING

Module leader:	Prof. Dr.-Ing. Benjamin Lehmann		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☒ Development and Fabrication of Intelligent Systems ☐ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in summer term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

This module conveys an in-depth knowledge and understanding about underwater acoustics and sonar systems. After successful completion of this module the students will be able to...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... describe the nature of underwater sound propagation;
- ... be are aware of the impact of sound transmission and receiving and discretization;
- ... demonstrate knowledge of the design principles of SONAR systems including antennas;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... evaluate typical sound velocity profiles, transmission loss, sound reflection/transmission at interfaces, sound scattering, ambient noise and sonar performance prediction;
- ... perform modeling of sound propagation using wave equation, homogeneous waveguide (image source and normal mode approach) and inhomogeneous waveguide (ray tracing);
- ... design sonar antennas with continuous/ discrete apertures of linear, rectangular and circular shape;
- ... evaluate the array gain and the directivity index;
- **...** reflect on system sonar signals processing chain with regard to quadrature demodulation, matched filtering, range resolution, doppler effect, pulse compression and signal detection;
- ... develop array signal processing methods with conventional beamforming (time/ frequency domain) as well as high resolution methods (MVDR beamformer, MUSIC algorithm and maximum likelihood DOA estimation);

Communication and cooperation

- ... do project work in an international team;
- ... present progress and results to supervisors and peers;
- ... assess results from experiment, evaluate in team and document scientifically;

Reflection of academic and professional identity

- ... reflect system design and test setup with regard to alternative designs;
- ... adhere to standards of professional action and documentation.

Course content:	▪ Fundamentals of Ocean Acoustics ▪ Sound Propagation Modeling ▪ Sonar Antenna Design ▪ Sonar Signal Processing ▪ Array Processing
Language of teaching:	English
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion Laboratory: Exercises and projects
Prerequisites:	None
Preparation/literature:	▪ B. Lehmann, Underwater Acoustics and Sonar Signal Processing, lecture notes, Hochschule Bremen ▪ L.M. Brekhovskikh, Y.P. Lysanov, Fundamentals of Ocean Acoustics, Springer, 2001 ▪ W.S. Burdic, Underwater Acoustic ▪ F. B. Jensen et al., Computational Ocean Acoustics, Springer, 2011 ▪ X. Lurton, An Introduction to Underwater Acoustics: Principles and Applications, Springer, 2010 ▪ H. L. van Trees, Optimum Array Processing, Part 4 of Detection, Estima-

	System Analysis, Prentice Hall, 1991.	tion and Modulation Theory, Wiley, 2002
Further information:	-	

Courses of the module

Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching form**	**Examination method(s), scope and duration**
Underwater Acoustics and Sonar Signal Processing	Benjamin Lehmann	2	Seminar (S)	Lab-integrating written (90 mins) or oral (30 mins) examination (IP)
Underwater Acoustics and Sonar Signal Processing	Benjamin Lehmann	2	Laboratory (L)	

3.16 WIRELESS COMMUNICATION

Module leader:	Prof. Dr.-Ing. Mario Goldenbaum		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☐ Development and Fabrication of Intelligent Systems ☒ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in summer term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

The goal of this module is to introduce the underlying theory, design techniques, and analytical tools of physical-layer wireless communications, focusing primarily on the core principles of point-to-point wireless system design. After successful completion of this module the students are able to...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... describe real bandpass signals in complex baseband domain;
- ... understand the properties of multipath wireless channels and their modeling (deterministic/statistical);
- ... know wireless communication techniques that increase reliability by exploiting channel diversity;
- ... explain how multicarrier modulation and spread spectrum can mitigate frequency-selective fading;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... evaluate wireless channel conditions and their impact on system performance;
- ... simulate multipath fading channels on a computer;
- ... design uplink and downlink spatial diversity schemes;
- ... set up an OFDM system for given bandwidth, data rate, and bit error rate requirements;
- ... reflect on how spread spectrum allows multiple users to share the same wireless spectrum;

Communication and cooperation

- ... work effectively in an international team on wireless communication problems;
- ... present concepts, progress, and results to supervisors and peers;
- ... assess results from experiments, evaluate in a team, and document scientifically;

Reflection of academic and professional identity

- ... reflect ideas critically and solution-oriented as essence of engineering thinking;
- ... adhere to standards of professional action and documentation.

Course content:	▪ Bandpass/baseband representations ▪ Path loss and shadowing ▪ Multipath propagation ▪ Statistical channel modeling (WSSUS, Rayleigh, Rice) ▪ Receive diversity (e.g., maximal ratio combining, equal gain combining)	▪ Transmit diversity (e.g., Beamforming, Alamouti space time coding) ▪ Multicarrier modulation ▪ The OFDM air interface ▪ Direct-sequence spread spectrum ▪ Frequency-hopping spread spectrum ▪ Spreading sequences & rake receiver
Language of teaching:	English	
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion Laboratory: Exercises, assignments, and experimental work	
Prerequisites:	None	
Preparation/literature:	▪ M. Goldenbaum, *Wireless Communications*, lecture notes, HS Bremen ▪ A. Goldsmith (2005), *Wireless Communications*, Cambridge University Press ▪ D. Tse and P. Viswanath (2005), *Fundamentals of Wireless Communication*, Cambridge University Press ▪ A. Molisch (2022), *Wireless Communications*, 3rd ed., John Wiley & Sons ▪ T. Rappaport (2024), *Wireless Communications: Principles and Practice*, 2nd ed., Cambridge University Press ▪ G. Stüber (2011), *Principles of Mobile Communications*, 3rd ed., Springer	

Further information:				
Courses of the module				
Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching form**	**Examination method(s), scope and duration**
Wireless Communication	Mario Goldenbaum	2	Seminar (S)	Lab-integrating written (90 mins) or oral (30 mins) examination (IP)
Wireless Communication	Mario Goldenbaum	2	Laboratory (L)	

3.17 MICROELECTRONIC CIRCUIT DESIGN

Module leader:	Prof. Dr.-Ing. Mirco Meiners		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☒ Development and Fabrication of Intelligent Systems ☒ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in summer term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

- The objective of this module is a project course in which students possess a thorough understanding of basic principles, challenges and limitations in microelectronic circuit design through a design project. After completion of this module students …

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- … have worked in project teams to generate a database that can (potentially) be sent out for fabrication,
- … have become familiar with microelectronic circuit design;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- … will have basic intuition by studying a selection of commonly used circuit and design techniques,
- … will be prepared for further study of mixed-technology systems;

Communication and cooperation

- … do circuit development and design in a team,
- … decide autonomous about organization and conduct of design steps,
- … present progress and results to supervisors and peers,
- … assess results from experiments, evaluate and analyze in a team and document scientifically,

Reflection of academic and professional identity

- … reflect system design and test setup with regard to alternative designs,
- … adhere to standards of professional action and documentation.

Course content:	▪ Design microelectronic circuits on printed-circuit board (PCB) and integrated-circuit (IC) level ▪ Amplifiers, integrators, filters, converters and auxiliary circuits ▪ Interfacing and aggregating microelectronic circuits
Language of teaching:	English
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion Laboratory: Experimental lab work, design project
Prerequisites:	None, recommended: Control Engineering, Signals and Systems, Microelectronics
Preparation/literature:	▪ Jaeger and Blalock, Microelectronic Circuit Design, 2022 ▪ Razavi, Microelectronics, 2014 ▪ Baker, CMOS: Circuit Design, Layout, and Simulation, 2010 ▪ Schaumann et. al., Design of Analog Filters, 2010 ▪ Additional papers to be handed out according to design topic
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Microelectronic Circuit Design	Mirco Meiners	2	Seminar (S)	Project Work (PA)

Microelectronic Circuit Design	Mirco Meiners	2	Laboratory (L)	

3.18 OPTICAL METROLOGY

Module leader:	David Hilbig		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	☐ Development and Fabrication of Intelligent Systems ☒ Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in summer term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

This module gives an introduction into optical measurement principles and optical metrology. Optical metrology includes a wide range of non-contact and therefore nondestructive measurement techniques for a broad field of different applications, from distance and shape measurement to the detection of residual gases. A selected set of common measurement systems are described according to their fundamental physical principles, with specific examples provided to demonstrate their practical application.

After completion of this module the students are able to ...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... understand the basics of optical metrology;
- ... understand the function of optical components;
- ... distinguish between different optical measurement principles and their applications;
- ... explain the benefits and drawbacks of different optical measurement systems

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... operate existing optical measurement systems;
- ... choose a suitable optical measurement technique with respect to given requirements;
- ... design and construct a basic optical measurement system;
- ... determine the targeted physical quantity from optical measurement data;

Communication and cooperation

- ... do project work in an international team;
- ... present progress and results to supervisors and peers;
- ... assess results from experiment, evaluate in team and document scientifically;

Course content:	▪ Fundamental physics for optical metrology ▪ Detection of optical radiation ▪ Various types of interferometer ▪ Basics and applications of Shack-Hartmann wavefront sensors ▪ Introduction to Optical Coherence Tomography ▪ Ray Tracing in measurement ▪ Light Detection and Ranging ▪ Optical sensors
Language of teaching:	English
Learning and teaching methods:	Seminar: Seminaristic teaching and discussion Laboratory: Experimental lab work
Prerequisites:	None
Preparation/literature:	▪ Hecht, Optics, Pearson ▪ Yoshizawa, Handbook of Optical Metrology, Taylor & Francis ▪ Mansuripur, Classical Optics and its Applications, Cambridge ▪ Malacara, Optical Shop Testing, Wiley ▪ Gasvik, Optical Metrology, Wiley

	▪ Additional literature to be handed out during seminar
Further information:	

Courses of the module

Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching form**	**Examination method(s), scope and duration**
Optical Metrology	David Hilbig	2	Seminar (S)	Portfolio (PF)
Optical Metrology	David Hilbig	2	Laboratory (L)	

3.19 SELECTED TOPICS OF ELECTRONICS ENGINEERING 2

Module leader:	Prof. Dr.-Ing. Friedrich Fleischmann		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	(☒) Development and Fabrication of Intelligent Systems (☒) Application of Intelligent Systems	**Scope and frequency of teaching:**	14 classes in summer term
Type of module and position in other study programs or continuing education offers:		Elective module in EMSS M.Sc., ENTEC M.Eng., KSS M.Sc.	

Learning outcomes:

After completion of the module, students are able to…

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- … understand and explain current research-, application- or technology-oriented concepts, methods and tools in a specific field of electronics engineering,

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- … assess concepts, methods and tools and select most appropriate ones for specific task,
- … apply those methods and tools to solve a specific task,
- … design, implement and document scientifically solution,
- … evaluate and discuss solution,

Communication and cooperation

- … do project work in a small team,
- … decide autonomous about organization and conduct of experiments,
- … present progress and results to supervisors and peers,
- … assess results from experiment, evaluate in team and document scientifically,

Reflection of academic and professional identity

- … reflect system design and test setup with regard to alternative designs,
- … adhere to standards of professional action and documentation.

Course content:	Depending on the topic, students are introduced to at least one current topic from research and/or practice in electronics engineering. Conceptual issues are discussed, methodological knowledge is imparted and what has been learned is applied to practical work. Examples of possible topics are	▪ Design of hardware for intelligent systems ▪ Artificial Intelligence for autonomous vehicles ▪ Design of automation systems ▪ Environmental research by remote sensing ▪ Greenhouse gas monitoring
Learning and teaching methods:	*Seminar:* Seminaristic teaching, discussion, coding sessions *Laboratory:* Project like experimental lab work	
Language of teaching:	English	
Prerequisites:	None	
Preparation/literature:	Students will receive a reading list at the beginning of the semester	
Further information:	Additional teaching and supportive material are available via aulis tool	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Selected Topics of Electronics Engineering 2	Teaching staff of MScEE or external lecturers	2	Seminar (S)	Lab-integrating written (90 mins) or oral (30 mins) examination (IP)
Selected Topics of Electronics Engineering 2		2	Laboratory (L)	

3.20 ELECTRONICS ENGINEERING PROJECT 2

Module leader:	Prof. Dr. Friedrich Fleischmann		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Non-dual program only: Technical elective module	**Contact hours (h):**	56h
		Self-study (h):	124h
Profile Allocation:	Depending on the specific project chosen	**Scope and frequency of teaching:**	14 classes in summer term
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

After successful completion of this module the students are able to ...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... identify and describe relevant project parameters like key engineering components, design tools and measurement equipment;

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... evaluate and structure a given project topic on EE regarding scheduling, monitoring and control;
- ... do self-directed studies within running research projects on electronics engineering under guidance of project manager;
- ... acquire knowledge and skills on given engineering topics by applying "learning by doing"

Communication and cooperation

- ... work effectively in a team;
- ... present scientific results on investigations, design and measurements
- ... improve the outcome of group meetings and discussions;

Reflection of academic and professional identity

- ... reflect system design and test setup with regard to alternative designs,
- ... adhere to standards of professional action and documentation.

Course content:	▪ Introduction to EEP: Subjects are related to the Electronics Engineering program and are usually inspired by current research projects in institutes i3m, IWSS and IAT ▪ Methods on scientific investigations in electronics engineering using literature and internet support ▪ Team work ▪ Project implementation, scheduling, monitoring and control ▪ Function, performance and application of project relevant engineering components, design tools and measurement equipment within a defined research project on optics, electronics, microsystems, communications, measurement and instrumentation ▪ Methods on evaluation of results, documentation and presentation techniques
Language of teaching:	English
Learning and teaching methods:	Project work
Prerequisites:	None
Preparation/literature:	References are announced at the beginning of the project.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Electronics Engineering Project 2	Professors of the program depending on project chosen	4	Project (P)	Project Work (PA)

NON-TECHNICAL ELECTIVES

2.21/3.21 INTERCULTURAL TEAMBUILDING I / II

Module leader:	Prof. Dr.-Ing. Friedrich Fleischmann		
ECTS points:	6 ECTS (2x 3 ECTS)	**Workload (h):**	180h (2x 90h)
Type of module and position in the program:	Dual and non-dual program: nontechnical elective module	**Contact hours (h):**	56h (2x 28h)
		Self-study (h):	124h (2x 62h)
Profile Allocation:	/	**Scope and frequency of teaching:**	14 classes each in winter and summer term
Type of module and position in other study programs or continuing education offers:		Elective module in EMSS M.Sc., KSS M.Sc.	

Learning outcomes:

After completion of the module, students are able to…

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- … understand the workings of the economy and the industries in which they are employed,
- … understand what motivates people at work and what causes people to behave as they do,

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- … distinguish culturally different habits and communication behaviour,
- … have an understanding for diversity and change management,

Communication and cooperation

- … understand the importance of communication in intercultural groups,
- … practise techniques designed to develop effectiveness both personally and in team roles,

Reflection of academic and professional identity

- … adhere to standards of professional action in intercultural environment.

Course content:	▪ Foundations of Group Behaviour ▪ Understanding Work Teams ▪ Communication ▪ Leadership ▪ Power and Politics
Learning and teaching methods:	Project Work and Tuition in Seminars
Language of teaching:	English
Prerequisites:	None
Preparation/literature:	▪ Students will receive a reading list at the beginning of the semester ▪ R. Kreitner, A. Kinicki, Organizational Behavior: Key Concepts, Skills & Best Practices, McGraw Hill, 2012 ▪ J. Mattock, Cross-Cultural Communication: The Essential Guide to International Business, Kogan Page, 2003 ▪ S.P. Robbins, T.A. Judge, Organizational Behavior, Prentice Hall,2016
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Intercultural Teambuilding I (S)	T. Müller, F. Fleischmann	2	Seminar (S)	Portfolio (PF)
Intercultural Teambuilding II (S)	T. Müller,	2	Seminar (S)	

	F. Fleischmann			

2.22/3.22 MODERN CONCEPTS OF PROJECT MANAGEMENT I / II

Module leader:	Prof. Dr.-Ing. Friedrich Fleischmann		
ECTS points:	6 ECTS (2x 3 ECTS)	**Workload (h):**	180h (2x 90h)
Type of module and position in the program:	Dual and non-dual program: nontechnical elective module	**Contact hours (h):**	56h (2x 28h)
		Self-study (h):	124h (2x 62h)
Profile Allocation:	/	**Scope and frequency of teaching:**	14 classes each in winter and summer term
Type of module and position in other study programs or continuing education offers:		Elective module in EMSS M.Sc., KSS M.Sc.	

Learning outcomes:

MODERN CONCEPTS OF PROJECT MANAGEMENT I:

After completion of the module, students are able to…

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- … known classical and agile project management,
- … know Kanban and visual planning and project controlling,

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- … select appropriate methods,
- … structure, plan and initiate projects successfully,

Communication and cooperation

- … collaborate and communicate in projects in a focused manner,
- … work in iterations,
- … monitor project status,

Reflection of academic and professional identity

- … adhere to standards of professional action in intercultural environment,

MODERN CONCEPTS OF PROJECT MANAGEMENT II:

After completion of the module, students are able to…

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- … known classical and agile project management,
- … know Kanban and visual planning and project controlling,

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- … select and evaluate a project including definition of life cycle and the role of a project manager,
- … implement and organize a project regarding scheduling, monitoring and control,
- … handle budgeting and costing,
- … apply tools PERT, CPM and Gantt Charts in scheduling,

Communication and cooperation

- … collaborate and communicate in projects in a focused manner,
- … work in iterations,
- … monitor project status,

Reflection of academic and professional identity

- … adhere to standards of professional action in intercultural environment.

Course content:	**MODERN CONCEPTS OF PROJECT MANAGEMENT I & II:** ▪ Methods of classical and agile project management ▪ Understanding working in teams ▪ Kanban and visual planning tools
Learning and teaching methods:	Project Work and Tuition in Seminars
Language of teaching:	English

Prerequisites:	None
Preparation/literature:	▪ Students will receive a reading list at the beginning of the semester ▪ C. Gray, E. Larson, Project Management: The Managerial Process, McGraw Hill, 2017 ▪ J. Meredith, S. Mantel, S., Project Management: A Managerial Approach, Wiley, 2015
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Modern Concepts of Project Management I (S)	N.N.	2	Seminar (S)	Portfolio (PF)
Modern Concepts of Project Management II (S)	N.N.	2	Seminar (S)	

2.23/3.23 TECHNOLOGY IN SOCIETY I / II

Module leader:	Tanja Müller		
ECTS points:	6 ECTS (3x 2 ECTS)	**Workload (h):**	180h (2x 90h)
Type of module and position in the program:	Dual and non-dual program: Non-technical elective module	**Contact hours (h):**	56h (2x 28h)
Scope und frequency of teaching:	14 classes each in winter and summer term	**Self-study (h):**	124h (2x 62h)
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:

TECHNOLOGY IN SOCIETY I:

This module explores the interplay between historic technological developments and paradigm shifts in societies due to these technologies. By tracing back the evolution of selected key innovations and socio-technological regimes students will gain a nuanced interdisciplinary perspective on technology. After completion of the module the students are able to …

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- go beyond the engineering towards an understanding of technology from a social science perspective,
- explain how technological developments shaped and transformed societal structures and social, institutions in history,
- understand which social and cultural frameworks were important for certain technological developments and innovations to become established,

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- analyze the interaction between technological innovations or selected historic breakthroughs and their socio-historic context applying key social science concepts,

Communication and cooperation

- critically evaluate and present how technological innovations influenced and transformed different sectors of society,
- apply problem-based Learning on cases of technological advancements, patents and societies,

Reflection of academic and professional identity

- discuss the role of well-known innovators and engineers and their professional dilemmas or ethical concerns, apply it to current situation.

TECHNOLOGY IN SOCIETY II

This module explores the relationship between technologies and their broader social, cultural or ethical implications. It critically examines how technologies shape societies and contribute to both solutions and challenges. After completion of the module the students are able to …

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- explain how technologies shape and transform society on an individual (micro) and collective (macro) level
- understand selected social sciences concepts and approaches (e. g. social norms, social structures and inequalities, social acceleration, post-growth approaches)
- develop a deeper understanding of technology from a social science perspective and appropriate research methods

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- critically evaluate technological developments in terms of sustainable lifestyle and exploitation of natural resources (e.g. rare earth elements) and solutions for preserving the planet and risks for humankind

Communication and cooperation

- critically evaluate and present how digital innovations influence and transform different sectors of society nowadays, evaluate solutions
- problem-based Learning on empirical studies or actual real-world of technology, technology assessment and sustainability

Reflection of academic and professional identity

- reflect on their own role as engineers, potential professional dilemmas and ethical concerns in future

Course content:	**TECHNOLOGY IN SOCIETY I** ▪ History of technological inventions, paradigm shifts for societies, socio-technical regimes and ideas of human

	- Social science/ sociological concepts (norms, values, social structure, inequalities…) - Selected historical case studies (e.g. automobile, jetliner) - Problem-based learning cycle **TECHNOLOGY IN SOCIETY II** - Social science approaches for technology in society (e.g. STS, social constructivist, ANT) and sociological concepts for analysis - Selected empirical studies on laboratory work and engineering science and real-world problems (e.g. digital inovations, artificial intelligence, automation…) - Ethical criteria - Problem-based learning cycle
Language of teaching:	English
Prerequisites:	None
Preparation/literature:	**TECHNOLOGY IN SOCIETY I** - Gobo, G. (Hrsg.). (2023). Science, Technology and Society: An Introduction. Springer International Publishing AG. https://doi.org/10.1007/978-3-031-08306-8 - Segal, D. (2019). One hundred patents that shaped the modern world (First edition). Oxford Scholarship Online. Oxford University Press. https://doi.org/10.1093/oso/9780198834311.001.0001 - Geels, F. W. (2005). Technological transitions and system innovations: A co-evolutionary and socio-technical analysis. Edward Elgar. - Journals: *Journal of Technology in Society*; *IEEE Technology and Society* - Further readings will be provided in class **TECHNOLOGY IN SOCIETY II** - Muldoon, J., Graham, M. & Cant, C. (2024). Feeding the Machine: The Hidden Human Labour Powering AI. Canongate Books. - Göpel, M. (2016). The Great Mindshift (Bd. 2). Springer International Publishing. https://doi.org/10.1007/978-3-319-43766-8 - Zuboff, S. (2019). The age of surveillance capitalism: The fight for a human future at the new frontier of power (Paperback edition). Profile Books. - Journals: *Journal of Technology in Society*; *IEEE Technology and Society* Further readings will be provided in class

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Technology in Society I	Tanja Müller	2	Seminar (S)	Portfolio
Technology in Society II	Tanja Müller	2	Seminar (S)	

2.24/2.24 RESEARCH METHODS I / II

<table>
<tr><td>**Module leader:**</td><td colspan="3">Prof. Dr.-Ing. Friedrich Fleischmann</td></tr>
<tr><td>**ECTS points:**</td><td>6 ECTS (2x 3 ECTS)</td><td>**Workload (h):**</td><td>180h (2x 90h)</td></tr>
<tr><td rowspan="2">**Type of module and position in the program:**</td><td rowspan="2">Dual and non-dual program: nontechnical elective module</td><td>**Contact hours (h):**</td><td>56h (2x 28h)</td></tr>
<tr><td>**Self-study (h):**</td><td>124h (2x 62h)</td></tr>
<tr><td>**Profile Allocation:**</td><td>/</td><td>**Scope and frequency of teaching:**</td><td>14 classes each in winter and summer term</td></tr>
<tr><td colspan="2">**Type of module and position in other study programs or continuing education offers:**</td><td colspan="2">Elective module in EMSS M.Sc., ENTEC M.Eng., KSS M.Sc.</td></tr>
</table>

Learning outcomes:

RESEARCH METHODS I:

After completion of the module, students are able to...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... penetrate a relevant section of a given subject area with regard to relevant questions and discussions of the scientific community,
- ... formulate their own scientific question,
- ... carry out scientific research,
- ... correctly summarize the state of the art in science and technology, establish essential references to the previously defined question and present own findings and conclusions,

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... correctly transfer the acquired knowledge (theory/findings) to further examples or application domains,
- ... search for relevant information for decision-making on the basis of an incomplete information base
- ... draw scientifically sound conclusions or make decisions, taking into account social and ethical findings.

Communication and cooperation

- ... present the findings to the whole group, discuss them and defend them against objections
- ... Critically reflect on the findings of others from a scientific perspective and give feedback
- ... Deal constructively with direct criticism of content

Reflection of academic and professional identity

- ... adhere to standards of professional action and documentation,
- ... pursue their own and other people's learning and work objectives in a self-directed way,
- ... place technological approaches in a social context, discuss and evaluate them.

RESEARCH METHODS II:

After completion of the module, students are able to...

Knowledge and understanding (extension, consolidation and understanding of knowledge)

- ... formulate their own scientific question
- ... correctly summarize the state of the art in science and technology, establish essential references to the previously defined question and present own findings and conclusions
- ... are familiar with patent research and patent application

Using, applying and generating knowledge (applying and transferring knowledge, Scientific innovation)

- ... search for relevant information for decision-making on the basis of an incomplete information base,
- ... apply tools PERT, CPM and Gantt Charts in scheduling,
- ... organize a project regarding scheduling, monitoring and control,

Communication and cooperation

- ... present the findings to the whole group, discuss them and defend them against objections,
- ... critically reflect on the findings of others from a scientific perspective and give feedback,
- ... write scientific publications and posters,
- ... phrase project proposals and patent applications,

Reflection of academic and professional identity

- ... adhere to standards of professional action and documentation,
- ... place technological approaches in a social context, discuss and evaluate them

Course content:	**RESEARCH METHODS I:** ▪ Research and scientific work ▪ Research ethics and rules of good scientific practice

	▪ Dealing with scientific literature, citation ▪ Planning and writing scientific essays ▪ Scientific lecturing, presentation and communication **RESEARCH METHODS II:** ▪ Finding a topic and beginning the scientific work ▪ Project and time management ▪ Documentation and reporting ▪ Scientific lecturing, scientific presentation and scientific communication ▪ Texts for the public, graphic design and poster design ▪ Project proposal and motivation letter ▪ Patents ▪ Entrepreneurship
Learning and teaching methods:	Seminar talk, project work and discussion
Language of teaching:	English
Prerequisites:	None
Preparation/literature:	Students will receive a reading list at the beginning of the semester.
Further information:	

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
Research Methods I (S)	T. Müller, F. Fleischmann	2	Seminar (S)	Portfolio (PF)
Research Methods I (S)	T. Müller, F. Fleischmann	2	Seminar (S)	

2.25/3.25 GERMAN LANGUAGE MODULE

Module leader:	Prof. Dr. Friedrich Fleischmann (conducted at Fremdsprachenzentrum Bremen)		
ECTS points:	6 ECTS	**Workload (h):**	180h
Type of module and position in the program:	Dual and non-dual program: Non-technical elective module taught in the 1. and 2. semester	**Contact hours (h):**	56h
Scope und frequency of teaching:	14 classes each in winter and summer term	**Self-study (h):**	124h
Type of module and position in other study programs or continuing education offers:			/

Learning outcomes:
German courses refer to the Common European Framework of Reference (CEFR); learning outcomes are given here for levels A 1 and A 2:
A 1=
Can understand and use familiar everyday expressions and very basic phrases aimed at the satisfaction of needs of a concrete type. Can introduce him/herself and others and can ask and answer questions about personal details such as where he/she lives, people he/she knows and things he/she has. Can interact in a simple way provided the other person talks slowly and clearly and is prepared to help.
A 2=
Can understand sentences and frequently used expressions related to areas of most immediate relevance (e.g. very basic personal and family information, shopping, local geography, employment). Can communicate in simple and routine tasks requiring a simple and direct exchange of information on familiar and routine matters. Can describe in simple terms aspects of his/her background, immediate environment and matters in areas of immediate need.

Course content:	Courses are taught on the basis of a course book (see literature)
Language of teaching:	German/English
Learning and teaching methods:	Language exercises in individual and group work, case studies, group projects, presentations and discussions
Prerequisites:	Completion of the previous level
Preparation/literature:	Course book for levels A 1 – B 1: “Netzwerk”, Klett-Verlag (to be purchased by students)
Further information:	AULIS link will be sent to students at the start of the respective course.

Courses of the module

Course title	Teaching staff	Contact hours per week	Learning and teaching form	Examination method(s), scope and duration
German Language Module (conducted at Fremdsprachenzentrum Bremen/FZHB)	German lecturers from FZHB	4	Seminar	Written exam (KL) or Oral exam (MP)

4.1 MASTER THESIS

<table>
<tr><td>Module leader:</td><td colspan="3">Prof. Dr.-Ing. Friedrich Fleischmann</td></tr>
<tr><td>ECTS points:</td><td>6 ECTS</td><td>Workload (h):</td><td>900h</td></tr>
<tr><td>Type of module and position in the pro-gram:</td><td>Mandatory module in the 3. Semester (three-semester program) or 4. Semester (four-semester program)</td><td>Contact hours (h):</td><td>56h Master’s Seminar
14h Master Project Consulting</td></tr>
<tr><td>Scope and frequency of teaching:</td><td>2 block courses per semester for the Master’s seminar
14h Master Project Consulting in groups of 5 students</td><td>Self-study (h):</td><td>830h</td></tr>
<tr><td colspan="3">Type of module and position in other study programs or continuing education offers:</td><td>/</td></tr>
<tr><td colspan="4">Learning outcomes: After completion of the module, students are able to...
Knowledge and understanding (broadening of knowledge, deepening knowledge, understanding of knowledge)
... familiarize themselves thoroughly with a scientific topic and sift through and read the literature for it,
Use, application and generation of knowledge (use and transfer, scientific innovation)
... methodically carefully analyze and evaluate scientific problems and approaches,
... find and use original literature,
... evaluate and describe solutions of scientific problems,
... identify deficits in the status quo of an area and derive suitable scientific questions from them,
... apply time management in theoretical and experimental investigations,
... evaluate and write thesis work including use of references,
... achieve a well-founded presentation of the solutions that appropriately emphasizes the importance of their own approach,
Communication and cooperation
... present the results of your own work at different work statuses twice in the master’s seminar and deal with questions and criticism,
... present the final results in the colloquium for the master’s thesis,
Scientific self-image or professionalism
... present complex content on topics from science and practice,
... work under supervision in a self-directed, autonomous way to complete Master Thesis,
... consider the role and responsibilities of an engineer in industry and society in their actions and outcomes.</td></tr>
<tr><td>Course content:</td><td colspan="3">The students deal with a current scientific question and, for the most part, indepen-dently develop the current state of research on this. In thesis work, students have to show that they are able to treat a scientific or technical subject self-directed within a given period of time and to integrate it into a larger interdisciplinary context.
The development / research task can be carried out in a university laboratory, in industry or at a partner institution in Germany or abroad, as desired.
The written part should be completed in English (exceptions in German language have to be approved by the examination board).
The results of the work are presented and discussed twice in the master’s seminar.
In a final colloquium, the subject will be presented and discussed.</td></tr>
<tr><td>Language of teaching:</td><td colspan="3">English</td></tr>
<tr><td>Learning and teaching methods:</td><td colspan="3">Master seminar: Presentation and discussion
Master Project Consulting: Scientific consulting of students’ projects
Master thesis: Supervised independent work</td></tr>
<tr><td>Prerequisites:</td><td colspan="3">80% of ECTS credits until second last semester of RSZ (48/72) ECTS</td></tr>
<tr><td>Preparation/literature:</td><td colspan="3">Current reading lists are made available at the beginning of the semester.</td></tr>
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Courses of the module				
Course title	**Teaching staff**	**Contact hours per week**	**Learning and teaching form**	**Examination method(s), scope and duration**
Master's Seminar	Professors of the program	4	Seminar (S)	Master Thesis + colloquium
Master Project Consulting		1	Group work (max. 5 students)	