Module Manual of Course of Studies

Electrical Engineering and Information Technology

10.4.2024
(valid from 09/24)

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
AUTOF	5	English	7	Compulsory	Winter Term

Module Title:
Autonomous Driving

Assignment to the Curriculum as a Compulsory Module
Electrical engineering and information technology

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Entry into autonomous driving and the technologies required for it, such as sensors, processing and actuators.

Course Director	Teaching Staff
Prof. Dr. Anestis Terzis	Prof. Dr. Anestis Terzis

Course Content
- Introduction autonomous driving and ADAS, SAE levels and milestones.
- Camera based environment sensing
- Image processing
- Safety systems
- Machine Learning Methods
- Cyber Security for ADAS/AD
- Connected Car - fundamentals, technologies and architectures
- Braking systems and steering actuators
- Active sensors, automotive radar and lidar sensor technology

Learning Outcomes

Professional Competence
- Be able to name systems in the automobile for increasing active and passive safety.
- Be able to name the components required for autonomous driving, such as sensors and actuators.
- Be able to classify automation functions in terms of SAE levels (degrees of automation).
- Be able to select sensors for specific requirements and evaluate their suitability.
- Know and apply methods of image processing.
- Be able to reproduce special procedures and transmission standards for vehicle radio systems.
- Calculate the required level / antenna gain for a radio link.
- Name and select machine learning methods for object recognition and classification tasks.
- Know and describe cyber security requirements and regulations.
- Know and describe the operation and design of braking systems and steering actuators.
- Be able to describe functionality and performance parameters of automotive radar sensors and lidar sensors.

Self Competence:
- - Assessing individual analytical and conceptual skills

Social skills:

References
- Own lecture notes.
- Hermann Winner, Stephan Hakuli , Felix Lotz, Christina Singer (Editors) : „Handbook of Driver Assistance Systems Basic Information, Components and Systems for Active Safety and Comfort“,Springer Cham, 2016.
- Anestis Terzis (Editor): „Handbook of Camera Monitor Systems - The Automotive Mirror Replacement Technology based on ISO 16505, Springer, 2016.
Further literature references will be given in the context of the respective actual realization of the course.

Form of teaching and learning	Lecture		
Exam Form	Written exam	**Preconditions**	none

Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 90h	Practice Time 0h	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
BA	15	English	7	Compulsory	Summer and Winter Term

Module Title:
Bachelor thesis with seminar

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
The bachelor thesis is the final part of the study program. During the course of the thesis, students deepen their knowledge within a specific subject area of the study program. A clearly defined task is worked on using engineering and scientific working methods. The knowledge and skills acquired in the previous studies are to be applied within the framework of an engineering project. Focusing on independent work, including project planning and project control, securing of results and presentation of results, is to be deepened.

Course Director	Teaching Staff
Prof. Dr. Silko Kruse	Teaching staff of faculty E

Course Content
- Independent development and implementation of a specialist topic
- Literature work
- Delimitation of the task
- Project control based on the application of project management methods
- Creative development of concepts to solve the task
- Evaluation of the concepts
- Implementation of the best solution
- Documentation of the progress and securing of results according to scientific and engineering standards and including an evaluation of the results in the report of the bachelor thesis
- Presentation of the final report of the bachelor thesis

Learning Outcomes

Students acquire the following competencies:

Professional Competence
Nach erfolgreichem Abschluss des Moduls können die Studierenden
- selbständige Ingenieurstätigkeit durchführen sowie
- Fachwissen und eigene Erfahrungen in die Arbeit einfließen lassen und effizient weitergeben.

Learning and methodological competence
Upon successful completion of the module, students will be able to
- carry out independent engineering work and
- incorporate specialist knowledge and their own experience into their work and pass it on efficiently.

Sozial- und Self Competence
Upon successful completion of the module, students will be able to
- use their own creativity to solve engineering problems as well as
- find their way around in an industrial or research oriented environment and use the resources available.

References

- Instructions for the bachelor thesis as manuscripts of the lecturers supervising the respective bachelor thesis, THU, 2022
- Original literature in relevant reference books and journals.
- Rosenblum Perry, C., Small, M.: The Fine Art of Technical Writing - Key Points to Help You Think Your Way Through Writing Scientific, Academic, and Technical Publications, Business Reports, and Website Text. CreateSpace Independent Publishing Platform, 2011
- Atherton, T.:Technical Report Writing and Style Guide - How to write even better technical reports, indepently published, 2020

Further literature references will be provided as part of the current implementation of the event.				
Form of teaching and learning	Project			
Exam Form	Report plus presentation		**Preconditions**	none
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 90h	Self Studies 360h	Practice Time	Total Time 450h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
COMTEC	4	English	2	Compulsory	Summer Term

Module Title:
Communication Technology

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Overview and basic understanding of the procedures, methods and protocols in communication networks, especially LAN, Internet and CAN. Basis for in-depth study of the Internet, networks, bus systems and transmission processes.

Course Director	Teaching Staff
Prof. Dr. Franz Aletsee	Prof. Dr. Franz Aletsee

Course Content
Internet and Web - in a nutshell: What is the Internet? Networks and services. Client-server principle. Internet and WWW.
Layered Model and Protocols: What is a Protocol? OSI layer model. Basic structure of a communication network.
Network layer in the Internet: IPv4 packet structure and addressing. IP and Ethernet. Routing. ICMP. MPLS. IPv6 overview.
Transport layer on the Internet: UDP and TCP. Retransmission, Flow and Congestion control. Socket API and implementation.
Transmission technology: Network structures. Information theory. Source Encoding/Compression. Cryptography.
Data link layer: Error detection (Parity, IP checksum, CRC). Error correction. Sequential control.
Transmission layer: Baseband transmission with line coding. Bandpass transmission with modulation. Working with power levels. Access control.
CAN Controller Area Network: Overview. Message format and MAC layer. Physical layer (differential transmission, arbitration).

Learning Outcomes
Professional Competence
- The students know and explain the modules of a digital transmission system.
- The students assess simple digital transmission systems and calculate characteristic values.
- The students know important network protocols and name their differences.
- The students explain the interaction of all components of a network application.
- The students know signals, message formats and methods of a CAN bus system.

Learning and methodological competence
- The students analyze given communication networks using the OSI layer model.
- The students discuss the advantages and disadvantages of digital transmission signals and processes.
- The students analyze application protocols based on TCP/IP/Ethernet using Wireshark.
- The students examine CAN signals using an oscilloscope and derive the messages.

Self Competence:
- • The students independently research questions that arise when analyzing networks.

Social skills:
- -

References

- Derr, F. / Pross, D.: *Detailed script and lab tutorials*, THU, WS22/23.
- Roppel, C.: *Grundlagen der Nachrichtentechnik: Übertragungstechnik und Signalverarbeitung*, Hanser, 2018.
- Zisler, H.: *Computer-Netzwerke - Grundlagen, Funktionsweisen, Anwendung*, Rheinwerk, 2020.
- Badach, A.; Hoffmann, E.: *Technik der IP-Netze - Internet-Kommunikation in Theorie und Einsatz*, Hanser, 2022.
- Tanenbaum; Feamster; Wetherall: *Computer Networks*, Springer Vieweg, 2021.
- Obermann, K.; Horneffer, M.: *Datennetztechnologien für Next Generation Networks,* Springer Vieweg, 2013.
- Schnell, G.; Wiedemann, B.: *Bussysteme in der Automatisierungs- und Prozesstechnik*, Springer Vieweg, 2019.
- Zimmermann, W.; Schmidgall, R.: *Bussysteme in der Fahrzeugtechnik*, Springer Vieweg, 2014.
- Further bibliographical references are given within the lecture.

Form of teaching and learning	Lecture plus laboratory

Exam Form	Written exam		**Preconditions**	Laboratory certificate
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 60h	Practice Time -	Total Time 120h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
CT	5	English	4	Compulsory	Summer Term

Module Title:
Control Theory

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Control Theory is a vital component of Automation Engineering.
and also a building block of a sound and comprehensive engineering training.
Control technology enables higher standards with regard to precision and robustness for automation systems. This is especially true when deployed in difficult conditions, e.g. with external disturbances acting on a system or the system itself being prone to model uncertainties or parameter variations over time.
Control systems use sensors, actuators and mathematical models of the automation system to improve system performance. In the course the most common and important tools and methods of classic control engineering are taught. Furthermore, the study of control engineering enhances the practioners ability to think in systems and provides the theoretical and practical tools for the analysis and optimization of complex technical systems.

Course Director	Teaching Staff
Prof. Dr. Michael Lux	Prof. Dr. Michael Lux

Course Content
General Concepts of („classical“) control engineering, e.g.:

- Basic elements and technical terms of control engineering
- Structure and definitions for closed loop control systems
- (Basic-)controller types and their characteristics

Methods for controller design, e.g.:

- Model function / „templates“ for controller design (in the time and frequency domain)
- Empirical Control Loop Tuning Procedures
- Pole-/Zero Cancellation
- Optimum criteria (Gain Optimum, Symmetric Optimum)
- Methods for remodeling and simplification of control loop (elements), inter alia the method of Equivalent Time Constant
- Cascade Control

Stability analysis of systems

- Analysis of stability in the frequency domain
- The (simplified) Nyquist-Criterion
- Degrees of stability and robustness: stability margin(s)

Electrical Circuitry Design for dynamic Elements, inter alia:

- Operational Amplifiers to implement transfer functions in electric circuits

Learning Outcomes

Professional Competence
The students…
- …know the most important technical terms and concepts of control engineering and theory, respectively, and are able to explain them
- …are capable to state and define the most important standard controller types
- …know important control design procedures as well as (mathematical) tools for the description, simplification and parametrization of control loops
- …are capable of calculating important characteristics of dynamic systems, (e.g. final values, stability etc.)
- …are adept at choosing an appropriate controller type for typical control problems
- …are capable of analyzing simple and moderately complex control loops with respect to dynamics, stability and stability margins and evaluate the results
- …design controllers for simple to moderately complex control systems according to established design procedures and are capable of using appropriate approximation procedures where necessary (and know the range of validity for these approximations)

Learning and methodological competence
- Studens are capable to model constituent arts of a dynamic system with appropriate mathematical tools as well as using state of the art simulation programs (MATLAB/Simulink) to simulate, analyze and evaluate the system

Sozial- und Self Competence:
- Students obtain and assess technical information
- Students practice and exercise in smaller groups

References

- Lux, M.: *Regelungstechnik* – Lecture Notes, THU WS23/24
- Dorf, R.C. und Bishop R.H.: *Modern Control Systems,* 10th Edition. Pearson Publishing Company, 2006

(the following, additional material is available in German language, only)
- Schumacher, W.: *Grundlagen der Regelungstechnik*, Vorlesungsskript TU Braunschweig, https://srv.ifr.ing.tu-bs.de/static/files/lehre/vorlesungen/gdr/Skript_GdR.pdf
- Föllinger, O.: *Regelungstechnik*, 12. Auflage, VDE Verlag, 2016
- Lunze, J.: *Regelungstechnik 1*, 6. Auflage, Springer, 2008

Additional bibliographic reference may be provided during classes.

Form of teaching and learning	Lecture (3 SWS), Laboratory (1 SWS)			
Exam Form	Written exam (90 min)		**Preconditions**	none
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 90h	Practice Time 0h	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
DSP	5	English	4	Compulsory	Summer Term

Module Title:
Digital Signal Processing

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Basics on digital processing of signals (sampling, spectral analysis, filtering)

Course Director	Teaching Staff
Prof. Dr. Dirk Bank	Prof. Dr. Dirk Bank

Course Content

1. System description with differential equation and difference equation
2. Sampling and reconstruction
3. Spektral analysis (DFT / IDFT and FFT / IFFT)
4. Digital filters (FIR filter and IIR filter)

Learning Outcomes

Professional Competence
The knowledge obtained in the module systems theory is extended to discrete representations of systems and to the objectives of digital signal processing.
The course establishes the basics for consecutive modules in all major fields of study.
The students know different forms of system description (continuous, discrete).
The basic mathematical descriptions for sampling, discrete Fourier transform, and digital filtering are known.

Learning and methodological competence
Stability analysis, calculation of frequency responses, and filter design can be mathematically realized.
The substantial problems of signal processing can be formulated and transferred into models.
Realizations in Matlab can be created and analyzed.
The basics of digital signal processing can be applied to solve practical problems.
Particular issues from the lecture are covered in the laboratory by means of simulation examples in Matlab.

Self Competence:
An additional homework enhances the own responsibility and decision-making in the field of digital signal processing.

Social skills: ./.

References

Own Script: Signal Processing, 2020
Kammeyer, Kroschel: Digitale Signalverarbeitung, Teubner, Stuttgart, 2009
Götz: Einführung in die digitale Signalverarbeitung, Teubner, Stuttgart, 1998
Lunze: Regelungstechnik 1, Springer, Heidelberg, 2003
Further bibliographical references are given within the lecture.

Form of teaching and learning	Lecture plus laboratory			
Exam Form	Written exam		**Preconditions**	Homework
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 90h	Practice Time 0h	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
DT1	5	English	1	Compulsory	Winter Term

Module Title:
Digital Technology 1

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Basic introduction to digital technology.
Basis for build-on topics, such as circuit synthesis with CAD and microprocessors.

Course Director	Teaching Staff
Prof. Dr. Franz Aletsee	Prof. Dr. Franz Aletsee, Prof. Dr. Dominik Stöckle

Course Content
Terms, circuit symbols, codes, Boolean algebra and basic functions.
Description and minimization of logic functions using truth tables, logic equations and KV maps.
Technical implementation: logic levels, CMOS, logic families.
Standard combinational logic systems: mux/demux, coder/decoder, arithmetic, ALU.
Implementation of generalized logic systems: PROM, PAL, PLD.
Flip-flops: basic flip-flop, RS-, D-, JK- and T-FF, MS-FF.
Standard sequential logic systems 1: registers, shift registers, applications.
Standard sequential logic systems 2: asynchronous/synchronous counters, FSM applications.
Semiconductor memory: ROM, RAM, DDR.

Learning Outcomes

Professional Competence
- The students describe and calculate logic circuits with text, truth tables, Boolean algebra, KV maps and logic circuit diagrams.
- The students know and compare implementation technologies of digital logic systems.
- The students describe and differentiate between combinational logic systems (e.g. codec, mux/demux, ALU) and sequential logic systems (e.g. registers, counters).
- The students analyse, design, implement and validate logic systems (combinational and sequential logic).
- The students know the basic principles and areas of application of semiconductor memories (e.g. ROM, RAM, DDR).

Learning and methodological competence
- The students apply Boolean algebra and basic logic circuits to solve digital logic problems.
- The students express logic circuits with text, truth tables, Boolean algebra, KV maps and logic circuit diagrams.
- The students understand and use data sheets of digital components.

Self Competence:
- -

Social skills:
- -

References

- Pross, Derr: *DT1 – Detailed Script, THU, WS22/23.*
- Reichardt: *Digitaltechnik und digitale Systeme: Eine Einführung mit VHDL,* De Gruyter, 2021.
- Fricke: *Digitaltechnik: Lehr- und Übungsbuch für Elektrotechniker und Informatiker,* Springer-Vieweg, 2021.
- Urbanski, Woitowitz: *Digitaltechnik,* Springer, 2012.
- Further bibliographical references are given within the lecture.

Form of teaching and learning	Lecture plus laboratory			
Exam Form	Written exam		**Preconditions**	none
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 75h	Self Studies 75h	Practice Time -	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
DT2	4	English	2	Compulsory	Summer Term

Module Title:
Digital Technology 2

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Basic introduction to the design and simulation of digital circuits using hardware description languages and by means of current development environments.

Course Director	Teaching Staff
Prof. Dr. Anestis Terzis	Prof. Dr. Anestis Terzis

Course Content
- Abstraction levels
- Hardware description language VHDL, Basic elements of VHDL code, operators, attributes, concurrent code, sequential code, structural description and hierarchical design.
- Simulation of digital circuits
- Programmable logic devices: PLD, CPLD, FPGA
- Interfaces and control of complex fast semiconductor memories like LPDDR4
- Practical course: Design, simulation and programming of FPGA with VHDL (e.g. control of a 7-segment display)

Learning Outcomes

Professional Competence
- Design and analyze combinational and sequential circuits for circuit integration.
- Know and apply hardware description with VHDL.
- Know programmable logic devices (e.g. PLD, CPLD, FPGA) and dimension them according to the application.
- Know and apply synthesis of complex digital circuits with VHDL.
- Verify complex digital circuits by means of simulation.
- Know and describe interfaces and control of complex fast semiconductor memories.
- Programming, debugging and functional testing of hardware components (e.g. in PLD, CPLD, FPGA) with current development boards.
- Describe and be able to apply complete design flow in a development environment.

Learning and methodological competence
-The students receive a thorough introduction to the digital integrated circuit technology. They get insight in the potential and restrictions in view of the digital circuit design for programmable logic integration.
-The students get acquainted with basic VHDL concepts. They describe the behavior of digital circuits theoretically using their knowledge in digital technology and perform simulations.
-The students consolidate their knowledge by design entry and circuit simulation with the latest industry standard software and digital hardware boards.
-Hardware experiments in the laboratory is provided in order to give a real world experience, which can be compared with the theory and the simulation results.

Self Competence:
- Assessing one's own analytical and conceptual skills

Social skills:
- Learning and working together as a team

References

- Own manuscript.
- Brock J. LaMeres, Introduction to Logic Circuits & Logic Design with VHDL, Second Ed., Springer 2019
- Volnei A. Pedroni, *Digital Electronics and Design with VHDL*, Morgan Kaufmann, 2008
- Further bibliographical references are given within the lecture.

Form of teaching and learning	Lecture plus laboratory

Exam Form	Written exam		**Preconditions**	Laboratory certificate
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 60h	Practice Time 0h	Total Time 120h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
DISTSYS	5	English	6	Compulsory	Only Summer Term

Module Title:
Distributed Systems

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
This course teaches the basic skills and abilities of an electrical engineer in the field of distributed systems. Modern information systems, especially in the field of IoT, are spatially and logically distributed. The module defines the term distributed system, describes architectures and communication protocols typical for IoT systems. It enables the modeling and implementation of distributed applications with special attention to the classic protection objectives regarding IT security.

Course Director	Teaching Staff
Prof. Dr. Markus Hahn	Prof. Dr. Markus Hahn

Course Content

- Modeling of distributed systems
- Basics: design goals, architecture types, reference models, network components
- Processes, threads and virtualization of distributed systems
- Communication: Sockets, TCP and UDP, Socket API, MQTT
- Naming services: Namespaces and resolution, flat naming
- Time, concurrency and coordination in distributed systems
- Replication: introduction, quorums, broadcast replication
- Consensus: Byzantine failures, blockchains, consensus mechanisms
- IT security: general tasks, firewalls, NAT, cryptography

Learning Outcomes

Students will acquire the following competencies:

Professional Competence
- Enumerate and describe the essential tasks and design goals of distributed systems.
- Model, analyze and, if necessary, optimize distributed systems and their architecture
- Design the communication of a computer network and realize it under laboratory conditions
- Virtualize elements of a distributed system
- Evaluate a distributed system according to important aspects of IT security

Learning and methodological competence
- Systematically determine errors and solve problems in distributed systems
- Decompose complex tasks into subtasks and combine partial solutions into an overall solution

Self Competence:
- Assessing one's own analytical and conceptual skills

Social skills:
- Actively participate in small groups and develop solutions together
- Describe and present solutions as a team

References

- Own script.
- Maarten van Steen and Andrew S. Tanenbaum. Distributed Systems. CreateSpace Independent Publishing Platform, 2017.

- Christian Baun. Computernetze kompakt: Eine an der Praxis orientierte Einführung für Studium und Berufspraxis. Springer. 2020.
- Kuros, Ross: Computer Networking: A Top-Down Approach, 2012.

Further literature references will be given in the actual conducted course.

Form of teaching and learning	Lecture plus laboratory			
Exam Form	Written exam		**Preconditions**	Laboratory certificate
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 90h	Practice Time 0h	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
EE1	6	English	1	Compulsory	Winter Term

Module Title:
Electrical Engineering 1

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Basic introduction to electrical engineering and key qualifications.

Course Director	Teaching Staff
Prof. Dr. Anestis Terzis	Prof. Dr. Anestis Terzis

Course Content
Part I
- Introduction (history, basics)
- Circuit of ideal two poles (sources, resistors, diode, transistor, operational amplifier)
- Semiconductors (Diode, Transistor)
- Operational amplifier (basic circuits)
- Calculation of networks

Part II
- Learning through laboratory work

Learning Outcomes
Upon successful completion of the module, students will be able to:
- Understand the physical principles of power conduction.
- Describe and apply the operation of ideal and real, passive and active devices.
- Analyze and calculate simple electrical networks using equivalent resistance method, equivalent source method, Superposition theorem, node potential method, and mesh current method.
- Understand the physical principles of basic semiconductor devices and the band model.
- Determine operating points in basic circuits with nonlinear devices and given characteristics.
- Determine and understand operating points, characteristics and transfer behavior of bipolar transistors.
- Create and calculate equivalent circuits of basic two-port network (e.g. Pi,T).
- Describe the small-signal behavior of a bipolar transistor using two-port network theory.
- Describe chain matrices in the context of operational amplifiers.
- Calculate simple operational amplifier circuits.

Professional Competence

Learning and methodological competence
- Record characteristic curves and prepare measurement and results reports.
- Calculate, build and measure operational amplifier circuits.
- Targeted and effective learning through self-study and laboratory work.

Self Competence:
- Assessing one's own analytical and conceptual skills.

Social skills:
- Learning and working together as a team.

References
- Own manuscript.

Further bibliographical references are given within the lecture.

Form of teaching and learning	Lecture plus laboratory			
Exam Form	Written exam		**Preconditions**	Laboratory certificate
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 90h	Self Studies 90h	Practice Time 0h	Total Time 180h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
EE2	5	English	2	Compulsory	Only Summer Term

Module Title:
Electrical Engineering 2

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
The lecture is part of the basic studies, builds in particular on the lecture Electrical Engineering 1 and requires in particular the knowledge of the behavior of direct current circuits. Furthermore, it presupposes knowledge of physical and mathematical fundamentals, in particular electricity theory, the theory of static electric and magnetic fields and their force effect on stationary and moving charges, the magnetism of matter, infinitesimal calculus and calculus with complex numbers.
The lecture deals with time-varying processes in linear circuits. The first part of the lecture is devoted to the fundamentals of the description of time-varying processes in linear circuits. After a brief review of the properties of static electric and magnetic fields and their description, the law of induction is treated and inductance is derived as an idealized model of a concentrated, reactive linear device based on a description of self-inductance. The description of technical arrangements by linear and nonlinear magnetic circuits leads to simple calculation methods for coils. The modeling of transformers is derived from the description of the phenomenon of mutual induction between conductor structures.
After a short introduction of capacitance as an idealized model for the second, concentrated, reactive linear component, the mathematical modeling and calculation of transient processes in linear circuits is introduced. Charging and discharging processes of coils and capacitors are treated, as well as transient processes and forced oscillations of simple oscillating circuits.
The mathematical description, characteristics and measurement of time-dependent currents and voltages leads to the treatment of sinusoidal processes in linear circuits. The central point here is the description and analysis of AC circuits with the aid of complex quantities and functions within the framework of the so-called complex AC calculus. The basic techniques of network analysis, pointer diagrams and the description of power in AC circuits are covered.
As applications of time-varying processes in linear circuits, the second part of the lecture deals with locus curves and frequency responses of two-poles, the modeling of real, passive two-poles by means of suitable equivalent circuits, the transmission behavior of linear two-ports and the detailed modeling of transformers.
The description of losses in conductors and coils at higher frequencies concludes the lecture content.
In addition to teaching the fundamentals of the description of time-dependent processes in electrical engineering, the lecture material is also intended to serve as an example for learning the principles of engineering modeling for various applications in electrical engineering. Central to this is the complex alternating current calculation and working with equivalent circuit diagrams.
As a compulsory module of the basic studies, the module teaches the fundamentals of the analysis of the dynamic behavior of linear circuits of electrical engineering. The module builds on the modules Electrical Engineering 1, Mathematical Foundations and Physics 1 and is closely interlinked with the module Mathematics for Electrical Engineering 1 by using the mathematical methods taught there.

Course Director	Teaching Staff
Prof. Dr. Roland Münzner	Prof. Dr. Jacqueline Gölz, Prof. Dr. Roland Münzner

Course Content
- Time-varying fields, self-inductance, inductance
- The magnetic circuit and calculation of coils
- Counter-induction and the modeling of transformers
- Charging and discharging processes on capacitors and inductors, simulation of linear networks with SPICE (transient analysis)
- Characteristics and measurement of time-dependent processes in linear circuits
- Processes with sinusoidal course in linear, electrical circuits
- Complex AC analysis for the analysis of linear circuits, simulation of linear networks with SPICE (AC analysis)
- Power in AC circuits
- Methods of linear network analysis
- Locational curves and frequency responses of two-poles

- Modeling of real, passive two-poles
- Transfer behavior of linear two-ports
- Transformer modeling
- Loss mechanisms in lines and cores at high frequencies

Laboratory exercises on coil design and measurement, characteristics of periodic current and voltage waveforms, modeling of real two-poles, and transmission behavior of two-ports.

Learning Outcomes

Students acquire the following competencies:

Professional Competence
After successful completion of the module, students will be able to
- describe coils and transformers by means of magnetic circuits and calculate their inductances for idealized cases,
- determine the time constants of charging and discharging processes on inductors and capacitors and determine their time curves,
- define the characteristics of periodic signals and determine them by measurement,
- analyze linear alternating current circuits with complex alternating current calculation,
- define and calculate apparent, reactive and active power,
- describe simple equivalent circuits of real, linear components,
- analyze frequency responses of simple, linear one-port and two-port circuits using locus curves and Bode diagrams and
- investigate the behavior of simple, linear networks using AC analysis and transient analysis in SPICE.

Learning and methodological competence
After successful completion of the module, students will be able to
- understand and explain simple derivations of laws of electrical engineering,
- apply the modeling of technical systems to simple, passive circuits with linear components, in particular using suitable equivalent circuit diagrams and abstract representations of frequency responses,
- apply the basic principles of modeling technical systems to the simulation of circuits with passive, linear components using SPICE simulations for the time and frequency domains, and
- apply the essential principles for the realization of measurement setups for the characterization of circuits in the frequency domain and by their time averages to concrete circuits.

References

- Lecture Notes Electrical Engineering 2. THU, 2022
- Makarov, S.N.; Ludwig, R.; Bitar, S.J.: Practical Electrical Engineering. Springer, 2019.
- Boylestad, R.L.: Introductory Circuit Analysis. Pearson Education, 2015.
- Hambley, A.R.: Electrical Engineering: Principles & Applications, Pearson, 2018.
- Kories, R.; Schmidt-Walter, H.: Electrical Engineering - A Pocket Reference. Springer, 2003.

Further literature references will be given in the context of the current implementation of the course.

Form of teaching and learning	Lecture plus laboratory			
Exam Form	Written exam		**Preconditions**	Laboratory certificate
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 75h	Self Studies 75h	Practice Time	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
EEP	10	English	6	Compulsory	Summer Term

Module Title:
Electrical engineering project

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Within the framework of the processing of a clearly defined task in the form of an engineering project, which is carried out independently in a small team, the knowledge and skills acquired in the previous studies are applied, including the methods of project management, the securing of results and the presentation of results.
The electrical engineering project is based on the working methods learned during the practical project as well as on the specialized knowledge acquired in the previous studies and prepares students for the bachelor's thesis in the implementation of engineering and scientific working methods.

Course Director	Teaching Staff
Prof. Dr. Roland Münzner	Teaching staff of faculty E

Course Content
- Development and implementation of a specialist topic under the guidance of the supervising lecturers
- Literature work
- Delimitation of the task
- Basic project management using methods of project management
- Creative development of concepts to solve the task and evaluation of the concepts
- Implementation of the best solution
- Securing of results according to scientific and engineering standards and including an evaluation of the results in the form of the report
- Presentation of the results within the framework of the final presentation

Examples of topics to be worked on are:
- Microelectronic circuits: Design of microelectronic circuits related to automotive electronics, automation or communication systems and their metrological investigation.
- Control engineering: modeling and simulation of control loops and vehicle dynamics problems, realization of HIL simulations, simulation and testing of synchronization algorithms in communication systems
- Microcomputer technology: Realization of computer networks with industry- or vehicle-typical bus systems, application of industry-standard tools for simulation, testing and realization of measurement methods and sensors
- Software systems: Design and implementation of software systems for operation and support of electrotechnical systems, especially embedded systems
- Communications engineering: development and investigation of components and methods, design and test of microwave circuits
- EMC: design, implementation and test of measurement equipment, metrological EMC investigation of objects

Learning Outcomes

Students will acquire the following competencies:

Professional Competence
After successful completion of the module, students will be able to
- carry out engineering activities, similar to the job-related and practice-related activities of a development engineer, largely independently, as well as
- incorporate and pass on specialist knowledge and their own experience in their work.

In particular, this means that students
- describe tasks, determine the state of the art, search for and evaluate solutions, implement, measure, test and validate solutions, and
- independently design, simulate, build and test electrical engineering systems.

Learning and methodological competence
After successful completion of the module, students will be able to
- assess and present their own work and results in principle and explain them in project meetings and
- plan and carry out the independent processing of a delimited task in a team using project management methods.

This means in particular that the students
- investigate, evaluate, compare and defend solution approaches and project results,
- plan and successfully complete projects independently and in a team-oriented manner (including project management and time planning),
- be able to independently structure and formulate technical reports and to argue, summarize and discuss solutions developed in oral presentations in front of an auditorium.

Sozial- und Self Competence
After successful completion of the module, students will be able to
- apply their own creative approaches to problem solving as well as
- find their way around a developmental and research-oriented, but clearly delineated environment and use the available resources.

References

- Instructions for the electrical engineering project as manuscripts of the lecturers supervising the respective project work, THU, 2022
- Original literature in relevant reference books and journals.
- Rosenblum Perry, C., Small, M.: The Fine Art of Technical Writing - Key Points to Help You Think Your Way Through Writing Scientific, Academic, and Technical Publications, Business Reports, and Website Text. CreateSpace Independent Publishing Platform, 2011
- Atherton, T.:Technical Report Writing and Style Guide - How to write even better technical reports, indepently published, 2020

Further literature references will be provided as part of the current implementation of the event.

Form of teaching and learning	Project			
Exam Form	Project and Presentation		**Preconditions**	Report
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence	Self Studies 300h	Practice Time	Total Time 300h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
ELMA	5	English	4	Compulsory	Summer Term

Module Title:
Elektrical Machines

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
In highly industrialized countries, roughly 60-70% of electric energy consumption is attributed to electrical machines. Factory automation and elektric traction would be inconceivable without electrical drives and even modern vehicles with combustion engines feature double-digit numbers of (smaller) electrical motors.
For the electrical engineer, a fundamental knowledge of the basics of electric motors is indispensable. The introductory course provides an overview of the most important technologies and technical terms of the subject as well as an overview of the most common and most important types of electrical machines and their respective fields.

Course Director	Teaching Staff
Prof. Dr. Michael Lux	Prof. Dr. Michael Lux

Course Content
Fundamentals of electrical machines, inter alia.:

- generation and types of electromagnetic forces
- important technical terms of the electrical machinery industry
- „natural“ torque-speed characteristics and their classifications
- typical load characteristics, stationary operating point and static stability
- specifications and characteristics of electrical machines

DC machines, inter alia:

- composition and operating principle
- equivalent (electrical) circuit
- stationary operating behavior
- mathematical model and simulation
- characteristics of externally excited, shunt wound, series wound and compound DC machines
- (speed) control methods
- fundamental overview of power electronics components for electric machines
- typical sensors for controlled drives and control strategies

Single- and three-phase AC-Machines including further variants and special drives, inter alia:

- universal (tool) machine
- Induction machine: Composition and operating principle, equivalent (electrical) circuit, current locus curve, torque-speed characteristic, Kloss Formula
- synchronous machine (sinusoidal three-phase and variant: inter alia BLDC, Stepper motors, Reluktance motors)

Learning Outcomes

The students…
- …know and reproduce the most importent technical terms and concepts of electrical machines and can explain them
- …can name the most common (standard) machine types and operation modes
- …understand the principle of electromagnetic energy conversion in electrical machines and can explain it
- …know the different types of electrical machines and their characteristics, can name these and explain the advantages and disadvantages of a certain machine type for certain applications
- …know the most important setting procedures and adjustments for the characteristics of individual electrical machines
- …know the most important sensors and power electronic components for electric machines and can explain their basic working principle or mode of operation

Learning and methodological competence
- Studens can model and simulate individual components of electric machines or an entire drive system with appropriate software tools, e.g. in Matlab/Simulink
- Students understand technical terms, specifications and characteristics of electrical machines in data sheets and can read and interpret typical diagrams
- Students understand typical requirements for electrical machines and can select and calculate the correct dimensions of a motor

Sozial- und Self Competence:
- Students obtain and assess technical information
- Students practice and exercise in smaller groups

References

- Lux, M.: *Elektrische Maschinen* – Eigenes Lückenskript, THU WS23/24
- Kröger, C.: Elektrische Maschinen, Vorlesungsskript, THU
- Hagl, R.: *Elektrische Antribstechnik*, 3. Auflage, Springer Vieweg, 2021
- R. Fischer. *Elektrische Maschinen*. Hanser, 2004
- A. Kremser. *Elektrische Maschinen und Antriebe*. Teubner, 2004.
- G. Müller, B. Ponick. *Grundlagen elektrischer Maschinen*. Wiley- VCH
- Schröder, D. und Kennel, R.: *Elektrische Antriebe - Grundlagen,* 7. Auflage. Springer Vieweg, 2021

Further literature references will be provided as part of the current implementation of the event

Form of teaching and learning	Lecture (3 SWS), Laboratory (1 SWS)			
Exam Form	Written exam (90 min)		**Preconditions**	Laboratory certificate
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 90h	Practice Time 0h	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
EMC	5	English	6	Compulsory	Only Summer Term

Module Title:
Electromagnetic Compatibility

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Electrical and electronic assemblies in modern control, regulation or production systems, in aircraft and motor vehicles or even in data processing systems exhibit an increasing packing density. The spatial proximity of electronic assemblies, the constantly increasing clock and data rates of digital assemblies and line-bound communication systems, the increasing clock rates of switched power electronic assemblies and the almost complete utilization of the frequency spectrum up into the GHz range for communication applications via radio lead to constantly increasing problems of mutual electromagnetic interference of electrical and electronic assemblies and devices.
Therefore, all devices containing electrical components must be developed and tested according to EMC aspects in accordance with the EMC law. The lecture is thus aimed at all future engineers involved in the development, planning or installation of electrical equipment or systems.
As a compulsory module in the Power Electronics and Power Engineering major, the module teaches the fundamentals of electromagnetic compatibility with a focus on the analysis and interference suppression of EMC problems in combination with suitable modeling and metrological investigations. The module builds on the modules Electrical Engineering 2 and Electronics and Power Electronics.

Course Director	Teaching Staff
Prof. Dr. Roland Münzner	Prof. Dr. Roland Münzner

Course Content
- Basics of EMC and legal framework
- EMC-compliant design with regard to high-frequency interference - An introduction
- EMC measurement technology for emitted interference and immunity in the RF range
- Mains disturbances and power quality - EMC in the 50Hz mains and at high powers
- Linear and non-linear EMC components
- EMC on the printed circuit board: design guidelines, design of low-interference circuits
- EMC in the electrical drive train of motor vehicles

Laboratory exercises on power integrity, signal integrity, noise emission and interference suppression of power electronic circuits, shielding, noise immunity testing, and power system disturbances.

Learning Outcomes

Students acquire the following competencies:

Professional Competence

After successful completion of the module, students will be able to
- explain the importance of electromagnetic compatibility in today's technical environment,
- apply the basic principles of EMC-compliant design and construction of electronic circuits, power electronics and electrical systems to simple cases,
- analyze and measure the electromagnetic coupling of electrical and electronic assemblies and systems,
- apply the methods of metrological recording of interference emission for standard-compliant and pre-compliance measurements as well as interpret corresponding measurements,
- assess the immunity of electronic circuits to interference and validate it by measurement,
- assess and metrologically validate the signal integrity of electrical communications systems,
- use filters and shielding measures to improve the EMC properties of modules and systems in simple cases and check their effect, and
- assess the interaction of systems operated on the electrical supply network and interpret corresponding measurements.

Learning and methodological competence

After successful completion of the module, students will be able to
- summarize complex problems, which encompass various sub-disciplines of electrical engineering, within the framework of suitable, highly simplified modeling and derive suitable improvement measures from this modeling (here: for the EMC behavior of the assemblies under consideration) as well as
- develop targeted technical solutions for complex problems (here: with regard to the EMC behavior of electronic assemblies) in the interplay of metrological investigations and theoretical considerations.

References

- Lecture Notes Electromagnetic Compatibility, THU, 2022
- Wiliams, T.: EMC for Product Designers. Newnes, 2016
- Paul, C.R.: Introduction to Electromagnetic Compatibility. Wiley, 2022
- Ott, H.: Electromagnetic Compatibility Engineering. John Wiley & Sons, 2009

Further literature references will be given in the context of the current implementation of the course.

Form of teaching and learning	Lecture plus laboratory			
Exam Form	Written exam		**Preconditions**	none
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 90h	Practice Time	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
ETS	5	English	3	Compulsory	Winter Term

Module Title:
Electronics

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
CMOS technology is by far the dominant semiconductor technology today. In this lecture, the necessary fundamentals of circuit design for analog and switched-mode CMOS circuits are taught.

Course Director	Teaching Staff
N. N.	N. N.

Course Content

- Basic Single-Transistor Amplifier Stages
- Operating Point Setting and Stabilisation
- Differential Amplifiers with Active Load
- Cascode- and Folded-Cascode-Stage
- Feedback (Negative and Positive)
- MOSFETs as Switches (NMOS, PMOS, CMOS [Transmission Gate])
- Switched-Capacitor Technology
- I/O-Circuitry of ICs & Interaction with On-Chip Protection Circuitry
- Power Amplifier
- A/D- and D/A-Converter

Learning Outcomes
Professional Competence
The students ..
- understand, analyze and dimension basic electronic circuits.
- calculate feedback circuitry and judge the stability of amplifiers with feedback-loop.
- are familiar with I/O-stages of ICs and understand their interaction with on-chip protection devices as well as the related operational risks.
- understand the properties of different power amplifier classes and are able do judge their pros and cons in different applications.
- evaluate the pros and cons of different A/D and D/A-converter architectures and can decide which architecture is best suited for a certain application.

Learning and methodological competence
- Analysis and dimensioning of analog circuits using mathematical methods.
- Computer-aided analysis and development of analogue and switched-mode electronic circuits.
- Understanding and usage of integrated (analog) circuits´ data sheets.

Self Competence:
- Assess own analytical and conceptual skills and transfer them to related areas.

Social skills:
- Joint development of problem solutions in the team.
- Accepting and fulfilling a functional role in a development team.

References

- Own script as well as exercises and sample solutions.
- Paul R. Gray, Paul J. Hurst, Stephen H. Lewis und Robert G. Meyer. *Analysis and Design of Analog Integrated Circuits*. Wiley, 2009. ISBN: 978-0470245996.
- Rudy J. van de Plassche. *CMOS Integrated Analog-to-Digital and Digital-to-Analog Converters*. Springer US: Springer US, 2003. ISBN: 978-1-4757-3768-4
- A. S. Sedra, K. C. Smith: *Microelectronic Circuits*, Oxford University Press, Oxford, 2019. ISBN: 978-0190853464.

• Ulrich Tietze, Christoph Schenk und Eberhard Gamm. *Electronic Circuits: Handbook for Design and Application*. Springer, 2008. ISBN: 978-3540004295. • Further bibliographical references are given within the lecture.				
Form of teaching and learning	Lecture plus laboratory			
Exam Form	Written exam		**Preconditions**	Laboratory certificate
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 90h	Practice Time 0h	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
GA1	5	Deutsch	1	Compulsory	WS

Module Title:
German A1 (consisting of German A1/1 (2 ECTS) plus German A1/2 (3 ECTS))

Assignment to the Curriculum as a Compulsory Module

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Despite large parts of an engineers working environment being focused on English, electrical engineers and students in Germany need to be able to communicate with their working and research environment in German. Therefore, several modules cover basic and lower intermediate levels of German as well as technical German in order to enable students to perform effectively and interact with their environment.

Course Director	Teaching Staff
Language center	Dr. Stefan Fodor, Benjamin Ködel, Tatjana Gremer

Course Content

Culture:
- Cultural impressions
- Special places
- Famous festivities

Language:

- Conversations with others (introduction, welcome)
- Information about yourself (job, residence, nationality), ask for information of others
- Information about friends and family (relations, appearance)
- Name, order, buy and rate food
- Office environment (technology, computer, telephone)
- On trip (hotel reservation, weather, complaints)
- Spare time and dates (planning, reporting)
- The past (experiences, newspaper)
- Information on residence and surrounding area (directions, establishment, rooms)
- Rules of daily life (traffic, environment)
- Information on clothing (describe, rate, buy, compare)
- Information on health and body (body parts, nutrition, medical condition)
- Spelling, count up to 1.000.000, colour, weekday, month, season

Learning Outcomes

Students acquire the following competencies:

The module "German A1" consists of two consecutive courses ("Deutsch als FremdLanguage Grundstufe 1" and "Deutsch als FremdLanguage Grundstufe 2"), after completing both courses:

After completing this module, students understand and use familiar everyday expressions and very basic phrases aimed at the satisfaction of needs of a concrete type. Can introduce him/herselves and others and can ask and answer questions about personal details such as where they live, people they 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. Students are qualified to introduce themselves and others.

The module "German A1" correlates with level A1 of the Common European Framework for Languages.

References

- Kursbuch „Menschen A1“, Hueber Verlag, München 2022.
- Arbeitsbuch „Menschen A1“, Hueber Verlag, München 2022.

Further literature references will be provided as part of the current implementation of the event

Form of teaching and learning	As defined by examination regulations			
Exam Form	As defined by examination regulations		**Preconditions**	As defined by examination regulations
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 120 (60+60)	Self Studies 30 (15+15)	Practice Time	Total Time 150

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
GA21	5	Deutsch	2	Compulsory	Summer Term

Module Title:
German A2.1

Assignment to the Curriculum as a Compulsory Module

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Despite large parts of an engineers working environment being focused on English, electrical engineers and students in Germany need to be able to communicate with their working and research environment in German. Therefore, several modules cover basic and lower intermediate levels of German as well as technical German in order to enable students to perform effectively and interact with their environment.

Course Director	Teaching Staff
Language center	Annemarie Mann, Andrea Fetzer

Course Content

Culture:

- Working culture
- Behaviour

Language:

- Talk about jobs and family (different types of jobs, family history)
- Preferences and wishes (likes and dislikes)
- Plan a trip or tate (with someone else, report about it, offer/deny something)
- Ask for help (getting/giving advice, suggestions)
- Visiting a restaurant (order, complain, pay)
- Celebration (thank someone, congratulate someone, express surprise)
- Write a postcard and e-mail, read newspapers, magazines and factual texts

Learning Outcomes

Students acquire the following competencies:

The module "German A2.1" consists of one course also labelled "Deutsch als FremdLanguage Grundstufe 3".

Students 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. Students are able to read simple texts and explain the context. Students plan their own activities and interact with others.

The module “German A2.1” correlates with level A2.1 of the Common European Framework for Languages.

References

- Kursbuch „Menschen A2“, Hueber Verlag, München 2022.
- Arbeitsbuch „Menschen A2“, Hueber Verlag, München 2022.

Further literature references will be provided as part of the current implementation of the event.				
Form of teaching and learning	As defined by examination regulations			
Exam Form	As defined by examination regulations		**Preconditions**	As defined by examination regulations
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 90h	Practice Time	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
GA22	5	**Deutsch**	3	Compulsory	Winter Term

Module Title:
German A2.2

Assignment to the Curriculum as a Compulsory Module

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Despite large parts of an engineers working environment being focused on English, electrical engineers and students in Germany need to be able to communicate with their working and research environment in German. Therefore, several modules cover basic and lower intermediate levels of German as well as technical German in order to enable students to perform effectively and interact with their environment.

Course Director	Teaching Staff
Languagecenter	Tatjana Gremer, Serena Müller, Susanne Schindler

Course Content

Language and Culture:

Talk about experiences (in languages, language courses, about work, colleagues)
Television (habits, likes and dislikes)
Visiting places (reservations, directions)
Travelling (habits, report)
Cultural events (inspire someone, convince someone, suggestions)
Working environment: job description, getting to work and around, showing interest in co-workers
Mobility (car, public transportation)

Learning Outcomes

Students acquire the following competencies:

The module "German A2.2" consists of one course also labelled "Deutsch als FremdLanguage Grundstufe 4".

Students 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. Students are able to read simple texts and explain the context. Students plan their own activities and interact with others.

The module “German A2.2” correlates with level A2.2 of the Common European Framework for Languages.

References

- Kursbuch „Menschen A2“, Hueber Verlag, München 2022.
- Arbeitsbuch „Menschen A2“, Hueber Verlag, München 2022.

Further literature references will be provided as part of the current implementation of the event.

Form of teaching and learning	As defined by examination regulations		
Exam Form	As defined by examination regulations	**Preconditions**	As defined by examination regulations

Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60	Self Studies 90	Practice Time	Total Time 150

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
MB	6	English	1	Compulsory	Winter Term

Module Title:
Mathematical Foundations

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Teaching of the mathematical basics that are used in studying electrical engineering.

Course Director	Teaching Staff
Prof. Dr. Thomas Hartmann	Prof. Dr. Thomas Hartmann

Course Content
Linear Algebra
One and multidimensional differential calculus and their applications
One- and multidimensional integral calculus and their applications
Simple numerical methods

Learning Outcomes

Students acquire the following competencies:

Professional Competence
- The different entry knowledges are compensated by repetition and deepening of the school material.
- Basic computing techniques of one- and multidimensional analysis as well as linear algebra have been learned
- First insights into numerical methods were gained.

Learning and methodological competence
- The mathematical way of thinking and working was learned by applying it to concrete problems and can be used successfully at least for similar problems

Self Competence:

Social skills:
- Learning and working together in groups is learned

References

- L. Papula Mathematik für Ingenieure, Vieweg, 2014…
- G. Strang Introduction to Lineare Algebra, Cambridge University Press, 2021
- G. Gramlich, Lineare Algebra, Fachbuchverlag Leipzig, 2014

Further literature references will be provided as part of the current implementation of the event

Form of teaching and learning	Lecture			
Exam Form	Written exam (120min.)		**Preconditions**	Written exam
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 90h	Self Studies 90h	Practice Time	Total Time 180h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
MET1	6	Englisch	2	Compulsory	Summer Term

Module Title:
Mathematics for Electrical Engineering 1

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
The transformations used in electrical engineering and signal processing are presented and how to use them is practiced. This creates the foundation for compulsory modules in the main studies.

Course Director	Teaching Staff
Prof. Dr. Thomas Hartmann	Prof. Dr. Thomas Hartmann

Course Content
Differential equations and systems of differential equations
Complex analysis
Description of signals and processes in the time and frequency domain
Splines and other numerical methods

Learning Outcomes
Students acquire the following competencies:

Professional Competence
Complex quantities are used correctly and calculations are made with certainty.
- Working with discrete and continuous functions in the time and frequency domain is mastered
- The most important transforms are familiar and mastered

Learning and methodological competence
- Description of physical and technical problems using differential and difference equations and subsequent solving by numerical and analytical methods

Self Competence:

Social skills:

References

- L.Papula, Mathematik für Ingenieure, Vieweg, 2014
- T.Frey, M.Bossert Signal- und Systemtheorie, Vieweg 2009
- H.Heuser Gewöhnliche Differentialgleichungen, Vieweg, 2009
- J.-R. Ohm, H. Lüke, Signalverarbeitung, Springer, 2015

Further literature references will be provided as part of the current implementation of the event

Form of teaching and learning	Lecture			
Exam Form	Written exam (120min.)		**Preconditions**	none
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 90h	Self Studies 90h	Practice Time	Total Time 180h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
MET2	5	English	3	Compulsory	Winter Term

Module Title:
Mathematics for Electrical Engineering 2

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Further applications of mathematics in electrical engineering are presented

Course Director	Teaching Staff
Prof. Dr. Thomas Hartmann	Prof. Dr. Thomas Hartmann

Course Content
Introduction to probability and statistics
Mathematical and statistical applications in electrical engineering
Discrete algorithms
Optimization techniques

Learning Outcomes

Students acquire the following competencies:

Professional Competence
Numerical knowledge is deepened.
- Important optimization algorithms are mastered.
- Greater ability to modeling

Learning and methodological competence
Problems from probability calculation and statistics can be worked on independently and critically.
Statistical statements are interpreted appropriately

Self Competence:

Social skills:

References

- M.Bossert, S.Bossert, mathematik der digitalen Medien, VDE-Verlag, 1017
- F.Hiller, G.Liebermann, Operations Research, McGraw-Hill 2014
- M.Spiegel, L.Stephens, Statistik, Mitp-Verlag, 2014

Further literature references will be provided as part of the current implementation of the event.

Form of teaching and learning	Lecture			
Exam Form	Written exam		**Preconditions**	none
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 90h	Practice Time	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
MCOT	5	English	3	Compulsory	Winter Term

Module Title:
Microcomputer Technology

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Microcomputers can be found in almost every electrical engineering product today, so being able to use them is a fundamental skill in electrical engineering

Course Director	Teaching Staff
Prof. Dr. Michael Schlick	Prof. Dr. Michael Schlick

Course Content

- Microcomputer basics
- How a computer works, microcomputer structure, input and output, microcontroller
- Programming & test environment, C for embedded systems
- I2C bus
- Machine code, stacks & subprograms, program breaks
- DMA & bus mastering, cache memory, memory protection & segmentation
- Embedded Systems Basics
- Embedded Operating Systems
- Analysis and development of programs for embedded systems

Learning Outcomes
After successfully completing the module, students can
- Understand the structure and function of a microcomputer and a microcontroller.
- Use and program peripheral components
- Analyze, create and test programs for embedded systems
- Understand the time behavior of a program and implement it.

Professional Competence
- The students master the tools for embedded development (integrated development environment, logic analyzer) and can use them purposefully …

Learning and methodological competence
- The students are able to familiarize themselves with programs for embedded systems and can expand them.
- The students can systematically search for errors in a system made up of hardware and software and fix them.

Self Competence:
- The students can independently organize and manage a simple embedded system development task…

Social skills:
- The students can create simple programs in a team

References

- Slide script
- Stallings, William: Computer Organization & Architecture. 10, Pearson Education, 2016.
- Wüst, Klaus: Mikroprozessortechnik. Fifth, Springer, 2017.

Further bibliographical references will be given in the module

Form of teaching and learning	Lecture (3SWS), Lab (1SWS)

Exam Form	Written exam (90 min)		**Preconditions**	Laboratory certificate
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 90h	Practice Time	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
PH1	5	English	1	Compulsory	Winter Term

Module Title:
Physics 1

Assignment to the Curriculum as a Compulsory Module
Electrical Engineering and Information Technology (1. term)

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
The contents of the course is fundamental for studying and understanding Electrical Engineering and Information Technology. The course is closely linked to the courses of Electrical Engineering 1 and Mathematics 1.

Course Director	Teaching Staff
N. N.	N. N.

Course Content

Introduction (Physics overview, particle physics, units, measurements, uncertainty of measurement, systematic and random uncertainties). **Point mechanics** (kinematics, dynamics, forces, Newton's Laws, momentum, work, potential and kinetic energy, power, conservation of energy, conservation of momentum, elastic and inelastic collisions). **Mechanics of rigid bodies** (center of mass, inertia, Steiner's rule, torque, rotational motion, rolling motion, angular momentum, conservation of angular momentum, gyroscopes). **Elektrostatics** (electric charge, el. field and el. forces, el. flux, el. field calculations, motion of charged particles in el. fields, el. potential, voltage, sources of voltage and sensors, el. dipoles). **Magnetostatics** (magnetic field strength, magnetic flux, magnetic flux density, Ampere's law, calculation of magnetic fields, Lorentz force and applications, Hall effect and sensors, magnetic dipoles, DC-motor). **Nonconducting materials in electric fields** (Capacitors and capacity, dielectics, types of polarisation, capacitor types, capacitors in series/ in parallel, capacitive sensors, Piezoelectric effect). **Materials in magnetic fields** (Polarisation, magnetization, Dia-, Para-, Ferro- and Ferrimagnetism, hysteresis, remanence). **Electrical Conduction** (resistance, resistivity, metals, semiconductors, superconductors, electrolytes, galvanic elements, gases). **Elektromagnetic Induction** (Induction experiments, Faraday's law, Lenz's law, eddy currents, shielding, skin effect, inductors, inductive sensors, inductance within a circuit, Maxwell's equations).

Learning Outcomes

Students acquire the following competencies:

Professional Competence

- The students know and apply the basics of mechanics, electrostatics und magnetostatics.
- They describe and explain the physical phenomenons and principles of these fields of physics.
- They know the SI of units, use physical quantities and their units with ease and estimate the order of magnitude of the values.
- They assess uncertainties of measurements and interpret the results.
- They designate and describe technical applications of physical effects in electrical engineering and sensor systems.

Learning and methodological competence

- They apply mathematical methods to describe and solve simple problems of physics and to predict results.
- They retrieve information from different sources.
- They employ a variety of strategies to solve scientific problems.

Self Competence:

- They manage subject-area contents and organize their studies.

Social skills:

- They communicate and explain scientific effects to a group.
- They solve problems in small teams.

References

- Young, Freedman: *University Physics with Modern Physics*. Pearson, 2020
- Young, Stadler: *Physics*. Wiley, 2022
- Tipler, Mosca: *Physics for Scientists and Engineers - Extended Version,* WH Freeman, 6th ed. 2021

Further literature references will be provided as part of the current implementation of the event

Form of teaching and learning	Lecture			
Exam Form	Written exam		**Preconditions**	Written exam
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 75h	Self Studies 75h	Practice Time 0h	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
PH2	5	English	2	Compulsory	Summer Term

Module Title:
Physics 2

Assignment to the Curriculum as a Compulsory Module
Electrical Engineering and Information Technology (2. term)

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
The contents of the course is fundamental for studying and understanding Electrical Engineering and Information Technology. The course is closely linked to the courses of Electrical Engineering 2 and Mathematics 2.

Course Director	Teaching Staff
N. N.	N. N.

Course Content

Oscillations (simple harmonic oscillation, initial response, damped oscillations, forced oscillations, resonance, Q-value; nonharmonic, chaotic; superposition, Fourier spectral analysis; coupled oscillators; mechanical then electromagnetic); **Waves** (propagation, wave equation and solutions, dispersion, phase velocity, group velocity; wave interference, standing waves; mechanical then electromagnetic); **Statistics** (Boltzmann, activation energy, glow emission, thermocouple); **Quantum physics** (Schrödinger's equation, wave functions, Eigenvalues, tunnel effect; atoms and spectral lines, Laser);
Semiconductor physics (Cristalline solid structure, bandmodel, Fermi statistics, intrinsic/extrinsic conduction, pn-junction, diodes (diode characteristics, diode equation, temperature dependence and effects of doping, rectifier, tunnel current, light emitting diodes, light detecting diodes, solarcells); transistors.

Learning Outcomes

Students acquire the following competencies:

Professional Competence

- The students know and are able to apply the basics of oscillations and waves and their relevance in electrical engineering and information technology.
- They are able to explain the function of simple electronic semiconductor components and applications.
- They understand simple quantum physical concepts and know their application in modern quantum devices.
- They know technical applications of the covered physical effects and their relevance in the field of electrical engineering and sensor technology.
- They understand the function of these applications and can compare and assess the advantages and disadvantages of different methods.
- They apply the learned measurement methods in selected experiments in the laboratory. They document the measurement results, evaluate and discuss them.

Learning and methodological competence

- They know and are able to apply scientific and technical problem-solving methods in the field of oscillations, waves, atomic physics and semiconductor physics.
- They apply mathematical methods to describe and solve problems of physics and to predict results.
- They are able to draw analogies in the covered sub-fields of physics.

Self Competence:

- The students work independently, structured and goal-oriented.
- They organize independently their studies.
- They document their work results.

Social skills:

- The students organize themselves in learning groups.
- They communicate and explain scientific effects to a group.
- They solve problems in small teams.

References

- Young, Freedman: *University Physics with Modern Physics*. Pearson, 2020
- Young, Stadler: *Physics*. Wiley, 2022

- Tipler, Mosca: *Physics for Scientists and Engineers - Extended Version,* WH Freeman, 6th ed. 2021

Further literature references will be provided as part of the current implementation of the event.

Form of teaching and learning	Lecture			
Exam Form	Written exam		**Preconditions**	Written exam
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 75h	Practice Time 15h	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
PE	5	English	4	Compulsory	Summer Term

Module Title:
Power Electronics

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Power electronics includes all kinds of electronic circuits for conversion of electric power. These circuits are key elements for electro mobility and distributed power systems.

Course Director	Teaching Staff
N. N.	N. N.

Course Content

- Basic Principles of Power Electronics.
- Semiconductor Devices for Power Electronics Applications.
- Line-Commuted Converters.
- DC-DC-Converters.
- Galvanically Isolated DC-DC-Converters.
- Inverters.

Learning Outcomes
Professional Competence
The students ..
- understand the basic principles of power electronics.
- understand the properties of different semiconductor devices and are able the chose the best suited devices for a given application.
- understand the function and are able to analyze and develop line-commuted converters, DC-DC-converters and inverters.
- evaluate the pros and cons of different power electronics circuit topologies.

Learning and methodological competence
- Analysis and dimensioning of power electronics circuits using mathematical methods.
- Computer-aided analysis and development of power electronics circuits.
- Understanding and usage of data sheets of power electronics devices.

Self Competence:
- Assess own analytical and conceptual skills and transfer them to related areas.

Social skills:
- Joint development of problem solutions in the team.
- Accepting and fulfilling a functional role in a development team.

References
- Own script as well as exercises and sample solutions.
- Further bibliographical references are given within the lecture.

Form of teaching and learning	Lecture plus laboratory			
Exam Form	Written exam		**Preconditions**	Laboratory certificate
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 90h	Practice Time 0h	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
PP	24	English	5	Compulsory	Winter Term

Module Title:
Practice project (Internship)

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Knowledge and competencies acquired during the course of study are applied to industrial issues and deepened within the framework of a central engineering project that is typical of the targeted professional practice and professional qualification. Insight into industrial processes and teamwork in an organizational structure (team, department) represent a central aspect of engineering education and are learned directly in the company on site. During preprational training students learn entral sub-methods of project management and securing results as well as decision-oriented preparation of information and presentation of results.
The module builds on the specialist knowledge of the first 4 semesters and provides an important foundation for the modules Electrical Engineering Project and Bachelor Thesis with Seminar.

Course Director	Teaching Staff
Prof. Dr. Jacqueline Gölz	Teaching staff of faculty E

Course Content
- Preparational Phase: Delimitation and structuring of tasks, project planning as well as project control and risk management for the processed engineering project during the internship. Instructions on how to do basic measurements, secure results and prepare technical reports during a laboratory block course
  Here, the delimitation and outline of the task as well as the project planning are documented within the scope of a start report for the project. The results of project control and risk management are documented in the final report and presented during the project presentation.
- Practical phase in a company with implementation of a central engineering project that is typical for the targeted professional practice and professional qualification. Here, central sub-methods of project management, engineering documentation for securing results, decision-oriented preparation of information and presentation of results are deepened.
- Follow-up event: Presentation, documentation and evaluation of the completed project.

Learning Outcomes

Students acquire the following competencies:

Professional Competence
After successful completion of the module, students will be able to
- apply and evaluate competences acquired during their studies to industrial problems in electrical engineering and information technology and
- plan, specify, implement, evaluate and communicate projects.

Learning and methodological competence
After successful completion of the module, students will be able to
- plan project work and carry it out in a team
- understand, evaluate and discuss industrial processes
- present and discuss results and
- set up and adhere to milestone plans.

Sozial- und Self Competence
After successful completion of the module, students will be able to
- solve engineering tasks together in teamwork,
- plan, organize and communicate tasks and results
- present a significant sub-project to fellow students and the supervisor in the internship seminar, including discussion of the results.

References

- Instructions on how to secure results and prepare technical reports as manuscripts from the instructors supervising the respective practical project, THU, 2022.
- Kerzner, H: Project Management: A Systems Approach to Planning, Scheduling, and Controlling, Wiley, 2022
- Greg Horine, Project Management Absolute Beginner's Guide, 2017
- Rosenblum Perry, C., Small, M.: The Fine Art of Technical Writing - Key Points to Help You Think Your Way Through Writing Scientific, Academic, and Technical Publications, Business Reports, and Website Text. CreateSpace Independent Publishing Platform, 2011
- Atherton, T.:Technical Report Writing and Style Guide - How to write even better technical reports, indepently published, 2020

Further literature references will be provided as part of the current implementation of the event.

Form of teaching and learning	Project			
Exam Form	Presentation		**Preconditions**	Report
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 30h	Self Studies 30h	Practice Time 660h	Total Time 720h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
PROGC	6	English	1	Compulsory	Winter Term

Module Title:
Programming in C

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
This subject teaches basic skills and abilities in the field of hardware-oriented programming in C. Mastering basic concepts and ways of thinking in programming is an indispensable prerequisite as an electrical engineer.

Course Director	Teaching Staff
Prof. Dr. Markus Hahn	Prof. Dr. Markus Hahn, Prof. Dr. Silko Kruse, Prof. Dr. Marianne von Schwerin

Course Content

- Basics: computer organization, programming concepts, number systems
- Language elements in C
- Input/Output in C
- Data types (int, double, float, char, bool, constants)
- Operators (unary, arithmetic, logical, bitwise, assignments)
- Flow control (if, switch)
- Flow control loops (while, for, do while)
- Functions (parameter passing, call by value, call by reference, library functions)
- Arrays (one and multi-dimensional)
- Pointers

Learning Outcomes

Students will acquire the following competencies:

Professional Competence
- Apply the basic principles of programming in C
- Understanding of algorithmic solution patterns and flexible application to new problems
- Development of maintainable and functional C programs using the correct syntax

Learning and methodological competence
- Analyze simple application problems with regards to a programmable solution
- Usage of tools like compilers, linkers and debuggers
- Practical problem solving: development of algorithms and structures in C, design, implement and test the program

Self Competence:
- Assessment of own analytical and conceptual skills

Social skills:
- Learning and working together in a team

References

- Own Script.
- Brian W. Kernighan, Dennis Ritchie: The C Programming Language
- Stephen Kochan: Programming in C (4th Edition), 2014.
- Paul Deitel, Harvey M. Deitel: C: How to Program (8th Edition), 2015.

Further literature references will be given in the actual conducted course.

Form of teaching and learning	As defined by examination regulations

Exam Form	Written exam		**Preconditions**	none
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 90h	Self Studies 90h	Practice Time 0h	Total Time 180h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
PROGCPP	6	English	2	Compulsory	Summer Term

Module Title:
Programming in C++ incl. Project Work

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
This subject teaches basic skills and abilities in the field of hardware-oriented programming in C++. Mastering basic concepts and ways of thinking in object-oriented programming is an indispensable prerequisite as an electrical engineer.

Course Director	Teaching Staff
Prof. Dr. Markus Hahn	Prof. Dr. Markus Hahn, Prof. Dr. Silko Kruse, Prof. Dr. Marianne von Schwerin

Course Content

- Introduction to object orientation
- Concepts in C++: classes, constructors and destructors
- Separation of interface and implementation
- Operator overloading
- Composition and inheritance
- Friend concept
- Static and dynamic polymorphism
- C++ strings and containers
- Stream concept
- File handling
- Programming standards
- Programming project
- Usage of a version control system

Learning Outcomes

Students will acquire the following competencies:

Professional Competence
- Capability to explain syntax and semantics of language constructs in C++ with a runtime environment
- Capability to explain concepts of procedural and object-oriented programming
- Understanding of algorithmic solution patterns and flexible application to new problems
- Design, implement and test algorithms and object structures in the context of a project
- Usage of programming guidelines to create comprehensible and maintainable programs in C++

Learning and methodological competence
- Design of object structures
- Analyze practical problems and design, implement and test a software solution for them
- Experienced handling of an actual C++ compiler and usage of debuggers
- Plan and develop small programming projects in a team

Self Competence:
- Assessment of own analytical and conceptual skills

Social skills:
- Learning and working together in a team
- Joint development of problem solutions in a team
- Communication and cooperation in different roles in a project

References

- Own script.
- Bjarne Stroustrup: The C++ Programming Language (4th Edition), 2013.
- Scott Meyers: Effective Modern C++: 42 Specific Ways to Improve Your Use of C++11 and C++14, 2014.

Further literature references will be given in the actual conducted course.

Form of teaching and learning	Lecture + lab			
Exam Form	Written exam		**Preconditions**	Laboratory certificate
Follow-Up Modules				
Prerequisites	Programming in C			
Module Effort	Attendence 90h	Self Studies 90h	Practice Time 0h	Total Time 180h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
PRM	5	English	7	Compulsory	Winter Term

Module Title:
Project Management

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study

Since projects are omnipresent in professional environments of all kinds, the competencies acquired from this module are certainly a profound and necessary basis for a later professional career.

Course Director	Teaching Staff
Prof. Dr. Christian Iniotakis	Prof. Dr. Christian Iniotakis

Course Content

Key content is:

- Project definition, goals and objectives, SMTYPE
- Work breakdown structure, work packages, milestones, and phases
- Project schedule, critical path, and float
- Cost budgeting, resource and capacity planning
- Risk management and stakeholder analysis
- Limitations of classic PM: Simultaneous Engineering, SCRUM, etc.
- Skills of a PM: leadership, motivation, communication, etc.

Learning Outcomes

Professional skills:

- Students know the basic terms of PM.
- Students understand the functioning of various PM sub methods.
- Students apply the PM sub methods on their own project.
- Students understand the limitations of classic PM and know basic aspects of agile methods.
- Students understand the variety of necessary skills for successful PM, in articular regarding leadership, motivation, and communication.

Methodological skills:

- Students graphically elaborate the progress and results of their own project.
- Students present their own project to fellow students.
- Students present in a given topical framework and time setting.

Other skills:

- Students apply insights, knowledge, and skills of the course - in particular of leadership, motivation, and communication - also to their everyday life.
- Students form student teams themselves.
- Students discuss about and agree upon a suitable project setting for their own team project.
- Students regularly work in teams on a fully selfresponsible basis, applying various PM methods to their team project and preparing the presentations.

References

- Jakoby, Projektmanagement für Ingenieure, 2015
- Neumann, Projektsafari, 2017
- Horine, Project Management Absolute Beginner's Guide, 2017
- Verzuh, The Fast Forward MBA in Project Management, 2015

Form of teaching and learning	Seminar			
Exam Form	Written exam		**Preconditions**	none
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60	Self Studies 90	Practice Time	Total Time 150

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
SENSB	5	English	4	Compulsory	Summer Term

Module Title:
Sensors and Bus Systems

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Almost all technical systems must be monitored with regard to their condition. Usually, sensors are used for this purpose. They acquire non-electrical or electrical measured variables and convert them into standardized electrical output signals. Depending on the level of integration, sensors perform tasks starting from converting the measurand into an electrical signal, signal conditioning, filtering up to digitization and standardization/coding. The understanding of every task perfomed by such a sensing system basic functions of this so-called measuring chain of bus-capable sensors is the focus of this course.

Course Director	Teaching Staff
Prof. Dr. Jacqueline Gölz	Prof. Dr. Dominik Stöckle, Prof. Dr. Jacqueline Gölz

Course Content
Basics of measurement technology based on DIN 1319
Sensor as transmission system: static transmission behavior and error description, measurement chain and sensor structures
Measurement signal processing: Common signal conditioning circuits for sensors as well as analog filtering
Digitalization and analog-to-digital converters and digital-to-analog converters
Sensing principles: Classification and conversion principles: resistive, inductive, capacitive and piezoelectric
Typical measurends of automation and process measurement technology
Bus systems in the automotive environment: CAN, ZigBee, FlexRay, Ethernet
Bus systems in automation and process technology: ASI, CAN, CANopen, PROFIBUS, Ethernet, Profinet, EtherCAT
Interface modules, gateways, basics of safe bus systems

Learning Outcomes

Students acquire the following competencies:

Professional Competence
After successful completion of the module, students will be able to
- undertand and calculate of parameters such as sensitivity, resolution and measurement uncertainty
- explain and determin (static) transmission behavior of sensors (also error description)
- understand common conditioning circuits for sensors and will be able to design: Focus on amplification, bridge configuration and counter circuits
- select and dimension simple filter topologies depending on the intended use
- understand function of ADC and DAC circuits
- classify sensing effects and to explain transmission behavior of sensors
- understand and apply basic computer buses in the various fields of work

Learning and methodological competence
After successful completion of the module, students will be able to
- transfer signal theory to the context of sensor technology: frequency response analysis, processing of sensor signals (analog and digital)
- explain parameters and to interpret diagrams (transfer functions) in datasheets
- calibrate sensors and to quantify error masures
- distinguish, understand and configure interface modules and gateways

Sozial- und Self Competence:
- Students obtain and evaluate technical information, independently
- Students practice and work in changing team constellations

References

- Gölz, J.: *Sensors and Bus Systems – Script and detailed lab tutorials*, THU, Stand WiSe23
- Regtien: *Sensors for Mechatronics*, Elsevier, 2018
- Fraden, J.: *Handbook of Modern Sensors: Physics, Designs, and Applications*, 5th Edition, Springer, 2015
- Tietze, U., Schenk, C., Gamm, E.: *Electronic Circuits: Handbook for Design and Application*, 2nd Edition, Springer, 2008
- Pallas-Areny, R.; Webster, J.: *Sensors and Signal Conditioning*, 2nd Edition, Wiley, 2012
- Marshall, P.S.; Rinaldi, J.S.*: Industrial Ethernet*. Third Edition, ISA, 2017
- Metter, M.; Bucher, R.: *Industrial Ethernet in der Automatisierungstechnik*. 2. Auflage, 2007.
- Zimmermann, Werner; Schmidgall, Ralf: *Bussysteme in der Fahrzeugtechnik*, Vieweg, 2014

Further bibliographical references are given within the lecture

Form of teaching and learning	Lecture (3 SWS), laboratory (1 SWS)			
Exam Form	Written exam (90 min)		**Preconditions**	none
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 90h	Practice Time 0h	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
SOFEN	5	englisch	4	Compulsory	Summer Term

Module Title:
Software Engineering

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
In order to successfully develop application systems, an electrical engineer must know how to systematically develop software and master common specification, design, implementation and testing techniques. Likewise, knowledge and experience in project-oriented work is necessary, as taught in this module.

Course Director	Teaching Staff
Prof. Dr. Markus Hahn	Prof. Dr. Markus Hahn, Prof. Dr. Marianne von Schwerin

Course Content

- Software development processes
- Requirements engineering, traceability and testing
- Platform-independent software development
- Modeling with UML (static and dynamic modeling) using a UML tool
- Design patterns
- Software quality
- Software project management
- Use of version management
- Transfer of the learned into a practical project

Learning Outcomes

Students will acquire the following competencies:

Professional Competence
- Define requirements for software solutions
- Understand and apply graphical modeling of software systems using UML
- Evaluate software designs
- Knowing design principles of software systems
- Developing software in a team
- Evaluate and assure the quality of software systems

Learning and methodological competence
- Implement and execute a software development process
- Write, analyze and verify requirements in software projects
- Designing software systems and specifying their structure and behavior using UML
- Use and apply modern software development tools

Self Competence:
- Develop a software project according to a process
- Usage of modeling methods in a practical project
- Assessment of own analytical and conceptual skills

Social skills:
- Develop a software project in a team
- Recognize and reflect on one's own role in small groups
- Communicate and cooperate with different stakeholders in the project

- Represent and discuss own ideas in the project team as well as expressing and accepting professional feedback

References

- Own Script.
- Ian Sommerville: Software Engineering, (10th edition), 2018.
- Martina Seidel et al: UML @ Classroom: An Introduction to Object-Oriented Modeling, 2015.
- Martin Hitz, Gerti Kappel, et.al: UML@Work. dpunkt, 2005.

Further literature references will be given in the actual conducted course.

Form of teaching and learning	Lecture plus laboratory			
Exam Form	Project and Presentation		**Preconditions**	none
Follow-Up Modules				
Prerequisites	Programming in C++			
Module Effort	Attendence 60h	Self Studies 90h	Practice Time 0h	Total Time 150h

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
SYS	5	English	3	Compulsory	Winter Term

Module Title:
Systems Theory

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Basics on Modelling and Simulation of technical Systems

Course Director	Teaching Staff
Prof. Dr. Dirk Bank	Prof. Dr. Dirk Bank

Course Content

1. Explanation of „Signals“ und „Systems“
2. Description in the time domain (complex representation of stationary signals, instationary signals, system description by impulse response and convolution, description by differential equations, signal flow diagram and simulation)
3. Description in the frequency domain (Fourier series, Fourier transformation, term „spectrum“, transfer function, system stability, methods of system representation)

Learning Outcomes

Professional Competence
The knowledge acquired in the modules mathematics and physics is applied for the development of engineering expertises. Procedures and methods for the description of signals and dynamic systems are developed. The prerequisites for modelling and simulation are developed. The module establishes the fundamentals for application specific subjects as control theory, signal processing, communication technology, and vehicle dynamics.

Learning and methodological competence
The students can apply different forms of system description (frequency response, differential equation, transfer function) and can transfer the forms into each other.
Essential system properties (e.g. damping, stability) can be extracted from the system descriptions.
The description forms can be transferred into simple simulation models in MATLAB and system simulations can be executed.
For simple systems , the physical relations can be independently transferred into a mathematical description as well as into a model.
Modelling and simulation as engineering methods are understood and can be applied to mechanical engineering (e.g. vehicle dynamics), communication technology, signal theory, and automation engineering.

Self Competence:

Social skills:

References

Own Script: Systems Theory, 2020
Mildenberger: System- und Signaltheorie, Teubner, 1995
Ohm, Lüke: Signalübertragung, Grundlagen der analogen und digitalen Nachrichtenübertragungssysteme, 11. Auflage, Springer, 2010
Further bibliographical references are given within the lecture.

Form of teaching and learning	Lecture plus laboratory			
Exam Form	Written exam		**Preconditions**	Laboratory certificate
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 90h	Practice Time 0h	Total Time 150h

Module Abbreviation As defined by examination regulations	ECTS As defined by examination regulations	Language **Deutsch**	Semester As defined by examination regulations	Type As defined by examination regulations	Regular Cycle SoSe

Module Title:
Technical German EET (alias Technical German B1)

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Despite large parts of an engineers working environment being focused on English, electrical engineers and students in Germany need to be able to communicate with their working and research environment in German. Therefore, several modules cover basic and lower intermediate levels of German as well as technical German in order to enable students to perform effectively and interact with their environment.

Course Director	Teaching Staff
Language Center	Benjamin Ködel

Course Content

Job-related vocabulary and idiomatic expressions at the engineering workplace, especially in electrical engineering
Conversation on the phone, in meetings, during presentations and negotiations
Written expression in e-mails and business letters
Creating resumes
Main features of the political system in Germany
Basic business management terms in the corporate context
Conveying important customs of German economic and corporate culture

Learning Outcomes
Students can understand the main points of clear standard input on familiar matters regularly encountered in work, school, leisure, etc. Can deal with most situations likely to arise whilst travelling in an area where the language is spoken. Can produce simple connected text on topics which are familiar or of personal interest. Can describe experiences and events, dreams, hopes & ambitions and briefly give reasons and explanations for opinions and plans. All of the aforementioned will contain a focus on job preparation in the field of engineering in corporations and SMEs in Germany.

The module “Technical German EET” correlates with level B1.1 of the Common European Framework for Languages with a content focus on topics of professional life for EET graduates in Germany.

References

- Kursbuch „Menschen B1“, Hueber Verlag, München 2022.
- Arbeitsbuch „Menschen B1“, Hueber Verlag, München 2022.
- Current news articles and English-German articles from magazines for technical language on intermediate levels (inch-by-inch and others)

Further literature references will be provided as part of the current implementation of the event

Form of teaching and learning	As defined by examination regulations		
Exam Form	As defined by examination regulations	**Preconditions**	As defined by examination regulations

Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60	Self Studies 90	Practice Time	Total Time 150

Module Abbreviation	ECTS	Language	Semester	Type	Regular Cycle
WC	5	English	3	Compulsory	Winter Term

Module Title:
Wired Communications

Assignment to the Curriculum as a Compulsory Module
EET

Classification and Significance of the Module in Relation to the Objectives of the Course of Study
Module in the Communication Systems major, which builds on "Fundamentals of Communication Technology/Grundlagen der Kommunikationstechnik" and deepens the aspects of wired transmission, traffic theory, cryptography and Internet application protocols.

Course Director	Teaching Staff
Prof. Dr. Franz Aletsee	Prof. Dr. Franz Aletsee

Course Content
- Overview: line and packet network, OSI layer model, switching technology, routing, queuing theory.
- Optical transmission technology (OSI 1): fiber, dispersion, attenuation, non-linearity, LED/laser, PIN photodiode, shot noise limit, measuring and testing.
- Transmission protocol (OSI 2): sequence control, HDLC, (Carrier) Ethernet, SDH, OTN.
- Switching Protocol (OSI 3): IP, CO/CL, Label Switching.
- Voice over IP: protocols, signaling, open source software.
- Network management with SNMP.
- Fundamentals of cryptographic procedures and protocols for secure data transport.

Learning Outcomes
Professional Competence
- The students describe, compare and evaluate structures and functions of digital communication networks.
- The students calculate queuing characteristics of communication networks.
- The students know the transmission, transport and switching protocols of wired networks and can compare them.
- The students calculate characteristic values of optical transmission systems and their components and can measure them.
- The students know terms, procedures and protocols used in IT security.

Learning and methodological competence
- The students analyze and validate complex wired communication systems in different levels of abstraction (from the block diagram to the bit structure).
- The students analyze and validate protocols from the different OSI layers (optical transmission, SDH, IP, VoIP, SNMP).

Self Competence:

Social skills:

References

- Derr, F.: *Script and detailed lab tutorials*, THU, Stand SoSe22.
- Roppel, C.: *Grundlagen der Nachrichtentechnik: Übertragungstechnik und Signalverarbeitung*, Hanser, 2018.
- Badach, A.; Hoffmann, E.: *Technik der IP-Netze - Internet-Kommunikation in Theorie und Einsatz*, Hanser, 2022.
- Tanenbaum; Feamster; Wetherall: *Computer Networks*, Springer Vieweg, 2021.
- Badach: *Voice over IP - Die Technik: Grundlagen, Protokolle etc.*, Hanser, 2022.
- Further bibliographical references are given within the lecture.

Form of teaching and learning	Lecture plus laboratory			
Exam Form	Written exam		**Preconditions**	none
Follow-Up Modules				
Prerequisites				
Module Effort	Attendence 60h	Self Studies 90h	Practice Time -	Total Time 150h