HOCHSCHULE
HAMM-LIPPSTADT

MODULE MANUAL

Bachelor's Degree

ELECTRONIC ENGINEERING

DEGREE: BACHELOR OF ENGINEERING

Validity period: September 1st 2023 to August 31st 2024 Valid

according to examination regulations from 20.11.2017

Content

Overview

Legend: ECTS - European Credit Transfer and Accumulation System, hpw – hours per week, WL – workload, CH – contact hours, SST – self-study time

Module Description	Module Abbreviation	Module Coordinator	ECTS Points	hpw	WL	CH	SST
Electronic Engineering 1	ELE-B-2-1.01	Prof. Dr.-Ing. João Paulo Javidi da Costa	5	4	150	60	90
Engineering Mathematics 1	ELE-B-2-1.02	Prof. Dr. Jan Eric Kyprianidis	5	4	150	60	90
Computer Science 1	ELE-B-2-1.03	Prof. Dr. Stefan Henkler	5	4	150	60	90
Physical Foundations	ELE-B-2-1.04	Prof. Dr. Emanuel Slaby	5	4	150	60	90
Industrial Design	ELE-B-2-1.05	Prof. Dr. Stefan Henklerl	5	3	150	45	105
Scientific Work	ELE-B-2-1.06	Dr. Birte Horn	5	4	150	60	90
Electronic Engineering 2	ELE-B-2-2.01	Prof. Dr. Jan Eric Kyprianidis	5	4	150	60	90
Engineering Mathematics 2	ELE-B-2-2.02	Prof. Dr. Jan Eric Kyprianidis	5	4	150	60	90
Computer Science 2	ELE-B-2-2.03	Prof. Dr. Stefan Henkler	10	7	300	105	195
Engineering Design	ELE-B-2-2.04	Prof. Dr. Emanuel Slaby	5	4	150	60	90
Audio and Video Technologies	ELE-B-2-2.05	Prof. Stefan Albertz	5	3	150	45	105
Electronic Engineering 3	ELE-B-2-3.01	Prof. Dr. Ali Hayek	5	4	150	60	90
Engineering Mathematics 3	ELE-B-2-3.02	Prof. Dr. Jan Eric Kyprianidis	5	4	150	60	90
Microcontroller	ELE-B-2-3.03	Prof. Dr. Stefan Henkler	10	6	300	90	210
Interactive Systems Design 1	ELE-B-2-3.04	Prof. Dr. Achim Rettbergl	5	4	150	60	90
Audio and Video Processing	ELE-B-2-3.05	Prof. Stefan Albertz	5	3	150	45	105

Module Description	Module Abbreviation	Module Abbreviation	ECTS Points	hpw	WL	CH	SST
Control Engineering	ELE-B-2-4.01	Prof. Dr.-Ing. João Paulo Javidi da Costa	10	7	300	105	195
Prototyping and Systems Engineering	ELE-B-2-4.02	Prof. Dr. Stefan Henkler	10	6	300	90	210
Interactive Systems Design 2	ELE-B-2-4.03	Prof. Dr.-Ing. Ali Hayekl	5	4	150	60	120
Business Communication	ELE-B-2-4.04	Dr. Birte Horn	5	3	150	45	105
Internship/Exchange Semester	ELE-B-2-5.01	Prof. Dr. Stefan Henkler	30	-	900	10	890
Hardware Engineering	ELE-B-2-6.01	Prof. Dr.-Ing Ali Hayek	10	7	300	105	195
Advanced Embedded Systems	ELE-B-2-6.02	Prof. Dr. Stefan Henkler	10	6	300	90	210
Bachelor Thesis	ELE-B-2-7.01	Prof. Dr. Stefan Henkler	12	-	360	-	360
Project Work	ELE-B-2-7.02	Prof. Dr. Achim Rettberg	8	-	240	-	240
Autonomous Systems A	ELE-B-2-6.03	Prof. Dr. Stefan Henkler	10	8	300	120	180
Embedded Electronic Engineering A	ELE-B-2-6.04	Prof. Dr. Achim Rettberg	10	8	300	120	180
Autonomous Systems B	ELE-B-2-7.03	Prof. Dr. Stefan Henkler	10	8	300	120	180
Embedded Electronic Engineering B	ELE-B-2-7.04	Prof. Dr.-Ing. Ali Hayek	10	8	300	120	180

Examination and Course Achievements

For the final pass of the modules, the exams in the module description named examination have to be provided. These are assessed and used to determine the module grade. The examination forms are regulated in the framework examination regulations (RPO) for the bachelor’s degree programs at Hamm-Lippstadt University of Applied Sciences.

For the passing of a certain module, different course achievements are to be included. Course achievements are not graded and are therefore not included in the module grade. Examination achievements can be taken without a successful achievement of the course achievement(s). A module is only considered completed when all examinations and all course achievements have been successfully completed. The module descriptions in this module manual deal with the course achievements that are part of the framework examination regulations (RPO) for the bachelor's degree programs at Hamm-Lippstadt University of Applied Sciences.

Compulsory Modules

Module Description	**Electronic Engineering 1**
Module Abbreviation	ELE-B-2-1.01
Module Coordinator	Prof. Dr.-Ing. João Paulo Javidi da Costa

ECTS Points	5	**Total Workload**	150
Weekly Contact Hrs	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Study Semester / Course Frequency / Duration	1st Semester / Winter Semester / 1 Semester

Qualification Objectives	The students acquire skills in the fundamentals of DC technology and transients. They can calculate and analyze direct current networks. They can calculate capacitances and inductances and calculate and analyze 1st and 2nd order transients.
Contents	• Voltage, Current, and Power • Resistance and Ohm’s law • Kirchhoff’s laws • Node voltage and mesh current analysis • Thévenin- and Norton equivalent • Capacitance and inductance • Transients of first- and second-order
Teaching Method	Lecture (2 hpw), Exercise (2 hpw)
Course / Teaching and Learning Methods	The lecture will be taught in the style of a seminar. In the exercises relevant tasks will be completed and the results will be discussed.
Examination Forms	Module exam as a written exam (90 minutes).
Workload / Contact Hours / Self-Study Time	150 / 60 / 90 Hours
Participation Recommendations	None.

Requirement for ECTS points	Passed module final exam.
Significance of the Module Grade for the Final Grade	2.5 / 210 of final grade (weighting of 0.5)
Module Use (in other courses of study)	-
Bibliography / Literature	• R. Hambley, Electrical Engineering: Principles and Applications, 6th ed. Pearson Education, 2014. • J. W. Nilsson and S. A. Riedel, “Electric Circuits,” Pearson Publisher, 11th Ed., 2018 • J. D. Irwin and R. M. Nelms, “Basic Engineering Circuit Analysis,” Wiley Publisher, 11th Ed., 2015 • J. A. Svoboda and R. C. Dorf, “Introduction to Electric Circuits,” Wiley Publisher, 9th Ed., 2013 • K. Alexander and M. N. O. Sadiku, "Fundamentals of Electric Circuits," McGraw Hill Education Publisher, 6h Ed., 2019 • M. Albach, "Elektrotechnik," Pearson Studium, 2011 • G. Hagmann, "Grundlagen der Elektrotechnik," Aula-Verlag, 2013 • W. Weißgerber "Elektrotechnik für Ingenieure 1," Band 1. Vieweg-Verlag

Module Description	**Engineering Mathematics 1**
Module Abbreviation	ELE-B-2-1.02
Module Coordinator	Prof. Dr. Jan Eric Kyprianidis

ECTS Points	5	**Total Workload**	150
Weekly Contact Hrs	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Study Semester / Course Frequency / Duration	1st Semester / Winter Semester / 1 Semester

Qualification Objectives	Students acquire skills in basic mathematical concepts and procedures. They can explain and apply basic concepts of logic and set theory. They can calculate with real and complex numbers and solve equations, inequalities and linear systems of equations. They can analyze sequences for convergence and functions for continuity. They can derive and integrate functions and solve 1st order differential equations. For typical tasks in the field of technical systems they can select and apply the appropriate learned methods and interpret the results.
Contents	• Logic, set theory, functions • Real and complex numbers, fractions, powers, roots, logarithms, trigonometry, equations and inequalities • Systems of linear equations • Sequences and limits • Differential calculus • Integral calculus • First-order differential equations
Teaching Method	Lecture (2 hpw), Exercise (2 hpw)
Course / Teaching and Learning Methods	The lecture will be taught in the style of a seminar. In the exercises relevant tasks will be completed and the results will be discussed.
Examination Forms	Module exam as written exam (90 minutes).
Workload / Contact Hours / Self-Study Time	150 / 60 / 90 Hours
Participation Recommendations	None

Requirement for ECTS points	Passed module final exam.
Significance of the Module Grade for the Final Grade	2.5 / 210 of final grade (weighting of 0.5)
Module Use (in other courses of study)	-
Bibliography / Literature	• Croft and R. Davison, Foundation Maths, 6th ed. Pearson Education, 2016. • Croft et al., Engineering Mathematics, 5th ed. Pearson Education, 2017. • G. James et al., Modern Engineering Mathematics, 5th ed. Prentice Hall, 2005.

Module Description	**Computer Science 1**
Module Abbreviation	ELE-B-2-1.03
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Points	5	**Total Workload**	150
Weekly Contact Hrs	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Study Semester / Course Frequency / Duration	1st Semester / Winter Semester / 1 Semester

Qualification Objectives	The students will acquire competencies in the basics of Computer Engineering: • The students will know the basic terms, methods and concepts of computer science. • They will know and be able to explain how a computer is built. • They will know the basic elements of switching algebra and will be able to independently create and explain simple circuits based on a description of the problem. • The students will know how an operating system works and will be able to explain it. • They will know the basics of programming languages and will be able to apply these on a small scale by using the basic methods and concepts of computer science. The theoretical and practical work will be a foundation for the analyzing of embedded systems and microcontrollers.
Contents	Fundamentals of Computer Architecture • Processors • Memory • Interfaces Fundamentals of System Software • Memory Management • Resource Management • Processes Introduction to Programming • Fundamentals of Programming • Variables, Strings • Methods, Functions, Control Structures

	• Structure of Programs In order to increase student comprehension of course materials, excursions may be taken (companies, fairs, museums, exhibitions, conferences, events, etc.)
Teaching Method	Lecture (2 hpw), Exercise (2 hpw)
Course / Teaching and Learning Methods	The lecture will be taught in the style of a seminar. In addition, the students will complete tasks during the contact hours under supervision of the instructor.
Examination Forms	Module exam as a written test (90 minutes).
Workload / Contact Hours / Self-Study Time	150 / 60 / 90 Hours
Participation Recommendations	None.
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	2.5 / 210 of final grade (weighting of 0.5)
Module Use (in other courses of study)	-
Bibliography / Literature	• Tanenbaum, Andrew S. Structured Computer Organization. Pearson, 6th Edition, 2013. • Tanenbaum, Andrew S. Operating Systems Design and Implementation, Pearson, 3rd Edition, 2006. • Tanenbaum, Andrew S. Modern Operating Systems, Pearson, 3rd Edition, 2007. • B. W. Kernighan and D. M. Ritchie, The C programming language. Englewood Cliffs, N.J.: Prentice Hall, 1988.

Module Description	**Physical Foundations**
Module Abbreviation	ELE-B-2-1.04
Module Coordinator	Prof. Dr. Emanuel Slaby

ECTS Points	5	**Total Workload**	150
Weekly Contact Hrs	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Study Semester / Course Frequency / Duration	1st Semester / Winter Semester / 1 Semester

Qualification Objectives	The students will know the basic physical phenomena, which will be needed in the continuing natural and engineering disciplines. The students will possess the competence to solve physical tasks in an engineering context and to apply the basic laws of physics. The competencies learned represent the basics of prototype development.

Contents	• Fundamentals of Mechanics:
	  ○ Kinematics and Dynamics
	• The Laws of Thermodynamics
	• Light and Optical Systems
	  ○ Geometric Optics, Wave Optics and Surface Phenomena

Teaching Method	Lecture (2 hpw), Exercise (2 hpw)
Course / Teaching and Learning Methods	The lecture will be taught in the style of a seminar. The teaching units will build on one another and will be based on the students' experiences. In addition, the students will complete tasks during the contact hours under supervision of the instructor. Care will be taken to ensure that every student is involved and obvious knowledge gaps will be immediately dealt with through in-depth explanation.
Examination Forms	Module exam as a written test (90 minutes).
Workload / Contact Hours / Self-Study Time	150 / 60 / 90 Hours
Participation Recommendations	None.

Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	2.5 / 210 of final grade (weighting of 0.5)
Module Use (in other courses of study)	-
Bibliography / Literature	• R. Shankar: “Fundamentals of Physics: Mechanics, Relativity, and Thermodynamics”, Open Yale Courses 2014, ISBN-10: 0300192207. • R. Shankar: “Fundamentals of Physics: Electromagnetism, Optics, and Quantum Mechanics”, Open Yale Courses 2014, ISBN-10: 0300212364”. • M. Alonso, E.J. Finn: “Physics”, Addison Wesley Pub Co Inc. 1992, ISBN-10: 0201565188. • D. Halliday, R. Resnick, J. Walker: “Fundamentals of Physics”, Wiley 2010, ISBN-10: 0470469080. • D. C. Giancoli: “Physics: Principles with Applications”, Pearson 2013, ISBN-10: 0321625927. • The Feynman Lectures on Physics, “Vol. I: The New Millennium Edition: Mainly Mechanics, Radiation, and Heat”. ISBN-10: 0465024939.

Module Description	**Industrial Design**
Module Abbreviation	ELE-B-2-1.05
Module Coordinator	Prof. Dr. Stefan Henklerl

ECTS Points	5	**Total Workload**	150
Weekly Contact Hrs	3	**Contact Hours**	45
Language	English	**Self-Study Time**	105

Study Semester / Course Frequency / Duration	1st Semester / Winter Semester / 1 Semester

Qualification Objectives	The students will have theoretical knowledge and practical experience in the field of design. They will know the fundamentals of abstraction, design and two- and three-dimensional shapes. The students will be able to develop design work with a low degree of complexity according to formal aesthetic rules and to evaluate them based on design quality criteria. The students will be enabled to sketch designs by hand and to use technical tools on the computer to implement them. The students will acquire skills to develop prototypes creatively.
Contents	Industrial Design (Lecture) • Design Elements, Basic Vocabulary • Shape, Proportion and Area • Color and Color Systems • Composition, Layout and Grid • Font, Typography and Symbols • Quality Criteria Industrial Design (Exercise) • Practical design experience through independently developed compositions and discussion of designed products • Introduction to digital editing and output technology • Introduction to professional design software
Teaching Method	Lecture (2 hpw), Exercise (1 hpw)
Course / Teaching and Learning Methods	Lecture and exercise. Project-based knowledge transfer in plenary discussion.

Examination Forms	Module exam as a written test (90 minutes).
Workload / Contact Hours / Self-Study Time	150/ 45/ 105 hours
Participation Recommendations	None.
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	2.5 / 210 of final grade (weighting of 0.5)
Module Use (in other courses of study)	-
Bibliography / Literature	• Bernhard E. Bürdek: Design: History, Theory and Practice of Product Design by (2005-04-08) • Jennifer Cole Phillips: Graphic Design: The New Basics: Second Edition, July 14, 2015 • Moritz Zwimpfer: 2d Visual Perception: Elementary Phenomena of Two-dimensional Perception. A Handbook for Artists and Designers. Oct 1, 2001 • Adriaan van Haaften: Freehand: Sketching skills for students of architecture Paperback. January 16, 2012

Module Description	**Scientific Work**
Module Abbreviation	ELE-B-2-1.06
Module Coordinator	Dr. Birte Horn

ECTS Points	5	**Total Workload**	150
Weekly Contact Hrs	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Study Semester / Course Frequency / Duration	1st Semester / Winter Semester / 1 Semester

Qualification Objectives	Students will be able to communicate adequately in the English language during their studies and future career by purposefully using methods and techniques of scientific communication: • They will understand how to communicate and correspond appropriately both verbally and in writing. • They will have the necessary knowledge to understand scientific and technical texts in English and to write English texts themselves. • They will have basic knowledge of scientific work that enables them to carry out project work, presentations and dissertations in a structured, scientifically correct and legally secure manner. • Furthermore, the students will acquire intercultural competencies, which they can apply to various communication scenarios. The students will have theoretical knowledge and practical methods for effective and efficient learning and working and will know models, strategies and techniques in the field of self-management. They will be encouraged to take new courses of action in a goal-oriented manner and to use methods to expand their self-management skills in the professional, academic and private sectors and to be able to constantly act in a more successful manner.
Contents	• Subject-specific development of language skills • Refreshing and strengthening grammatical knowledge • Editing and writing scientific and technical texts and articles • Technical conversation and communication • Presentations and lectures

	• Scientific work • Topic choice • Putting the research question and procedure into concrete terms • Research and evaluation • Conducting own scientific examinations • Structuring and organizing the contents • Scientific writing style • Source citation, copyright and plagiarism • Reflection and follow-up of conversations • Presentation • Visualization of presentations • Time and stress management • Self-reflection
Teaching Method	Seminar (2 hpw), Exercise (2 hpw)
Course / Teaching and Learning Methods	Individual and group work, presentations, reflection and feedback discussion and role playing to develop intercultural competencies. A professional excursion may be conducted as part of the course
Examination Forms	Module exam as a written exam (90 minutes) or term paper (7-10 pages) and in-class presentation (15 minutes) during the course of the semester.
Workload / Contact Hours / Self-Study Time	150 / 60 / 90 hours
Participation Recommendations	None
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	2.5 / 210 of final grade (weighting of 0.5)
Module Use (in other courses of study)	-
Bibliography / Literature	• Allen, David: Getting things done. The art of stress-free productivity. New York: Penguin, 2003. • Brieger, Nick; Pohl, Alison: Technical English Vocabulary and Grammar. Munich: Langenscheidt, 2004. • Chastain, Emma. How to write a research paper. New York: Barnes & Nobles Publ., 2006. • Crowley, Dermot. Smart work. Centralise, organize, realise. How to boost your productivity in 3 easy steps. John Wiley& Sons, 2016. • Maslow, A.H. Motivation and personality. New York: Harper, 1954. • Maier, Rolf and Engelmeyer, Eva. Zeitmanagement: Grundlagen, Methoden und Techniken. Offenbach: Gabal, 2004. • Rehborn, Angelika. Brückenkurs Wisschenschaftliches Arbeiten. Konstanz/München: UKV Lucius, 2015. • Skern, Tim. Writing Scientific English. Wien: UTB, 2009.

Module Description	**Electronic Engineering 2**
Module Abbreviation	ELE-B-2-2.01
Module Coordinator	Prof. Dr. Jan Eric Kyprianidis

ECTS Points	5	**Total Workload**	150
Weekly Contact Hrs	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Study Semester / Course Frequency / Duration	2nd Semester / Summer Semester / 1 Semester

Qualification Objectives	Students acquire skills in the fundamentals of alternating current technology. They are able to calculate and analyze AC circuits using phasors and complex impedances. They can describe filters by means of the transfer function and, for simple first-order filters, calculate the transfer function and create Bode plots. They can calculate the parameters of series and parallel resonant circuits. They can analyze and calculate amplifiers in simple circuits.
Contents	• Sinusoidal signals • Phasors and impedances • Circuit analysis with phasors and impedances • Power in AC circuits • Filter, transfer function, and Bode plots • First-order low-pass and high-pass filters • Series and parallel resonance • Second-order filters • Amplifiers
Teaching Method	Lecture (2 hpw), Exercise (2 hpw).
Course / Teaching and Learning Methods	The lecture will be taught in the style of a seminar. In the exercises relevant tasks will be completed and the results will be discussed.

Examination Forms	Module exam as a written exam (90 minutes).
Workload / Contact Hours / Self-Study Time	150 / 60 / 90 hours
Participation Recommendations	None.
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	2.5 / 210 (weighting of 0.5)
Module Use (in other courses of study)	-
Bibliography / Literature	• R. Hambley, Electrical Engineering: Principles and Applications, 6th ed. Pearson Education, 2014. • J. W. Nilsson and S. A. Riedel, “Electric Circuits,” Pearson Publisher, 11th Ed., 2018 • J. D. Irwin and R. M. Nelms, “Basic Engineering Circuit Analysis,” Wiley Publisher, 11th Ed., 2015 • J. A. Svoboda and R. C. Dorf, “Introduction to Electric Circuits,” Wiley Publisher, 9th Ed., 2013 • K. Alexander and M. N. O. Sadiku, "Fundamentals of Electric Circuits," McGraw Hill Education Publisher, 6h Ed., 2019 • M. Albach, "Elektrotechnik," Pearson Studium, 2011 • G. Hagmann, "Grundlagen der Elektrotechnik," Aula-Verlag, 2013 • W. Weißgerber "Elektrotechnik für Ingenieure 1," Band 1. Vieweg-Verlag

Module Description	**Engineering Mathematics 2**
Module Abbreviation	ELE-B-2-2.02
Module Coordinator	Prof. Dr. Jan Eric Kyprianidis

ECTS Points	5	**Total Workload**	150
Weekly Contact Hrs	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Study Semester / Course Frequency / Duration	2nd Semester / Summer Semester / 1 Semester

Qualification Objectives	Students acquire further skills in basic mathematical concepts and procedures. They can calculate with vectors and matrices. They can develop functions into their real and complex Fourier series and solve linear differential equations. For typical tasks in the field of technical systems, they can select and apply the appropriate methods learned and interpret the results.
Contents	• Vectors and matrices • Fourier series • Linear differential equations
Teaching Method	Lecture (2 hpw), Exercise (2 hpw)
Course / Teaching and Learning Methods	The lecture will be taught in the style of a seminar. In the exercises relevant tasks will be completed and the results will be discussed.
Examination Forms	Module exam as written exam (90 minutes).
Workload / Contact Hours / Self-Study Time	150 / 60 / 90 Hours
Participation Recommendations	None.
Prerequisite for ECTS points	Passed module final exam.

Significance of the module grade for the final grade	2.5 / 210 of final grade (weighting of 0.5)
Module Use (in other courses of study)	-
Bibliography / Literature	• A. Croft and R. Davison, Foundation Maths, 6th ed. Pearson Education, 2016. • A. Croft et al., Engineering Mathematics, 5th ed. Pearson Education, 2017. • G. James et al., Modern Engineering Mathematics, 5th ed. Prentice Hall, 2005. • G. James et al., Advanced Modern Engineering Mathematics, 4th ed. Prentice Hall, 2011. • D.G. Zill and W.S. Wright, Advanced Engineering Mathematics, 5th ed. Jones & Bartlett Learning, 2014.

Module Description	**Computer Science 2**
Module Abbreviation	ELE-B-2-2.03
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Points	10	**Total Workload**	300
Weekly Contact Hrs	7	**Contact Hours**	105
Language	English	**Self-Study Time**	195

Study Semester / Course Frequency / Duration	2nd Semester / Summer Semester / 1 Semester

Qualification Objectives	**Programming** Students will acquire the necessary knowledge to be able to implement software in a professional manner: • The students will understand the basic terms, methods and concepts of programming and be able to apply them. • They will be able to apply a programming language (currently C/C++) relevant for the software development and understand the basic concepts of object-oriented programming methodology. • They will be able to analyze problems from the programming practice by applying the methods of computer science. • Practical problems will be solved independently in the programming language learned by applying the fundamentals of object-oriented programming. The theoretical and practical work in the field of programming form the basis for implementing functions in software for microcontrollers. **Software Engineering** Students will acquire basic skills in software engineering: • After completing the lecture, students will have mastered the most important principles of Object-Oriented Analysis (OOA). • They will understand the relevant UML description tools and will be able to use them. • Students will be able to name the different phases of the software development process and apply different methods of requirements engineering.

	• They will know the rules of teamwork and will be able to apply them in their groups. The theoretical and practical work in the fields of programming and software engineering make up the basis that will allow students to master and design software-intensive systems. These include, for example, autonomous systems, which are the subject matter of other courses such as Microcontrollers and Advanced Embedded Systems.

Contents	**Programming**
	• Basics of programming languages
	  ○ Variables, Strings
	  ○ Data Types and Operators
	  ○ Logic
	  ○ Branching and Repetition
	  ○ Functions, Methods and Recursion
	  ○ Arrays
	• Basic Object-Oriented Programming Concepts
	  ○ Classes and Objects
	  ○ Attributes and Methods
	  ○ Encapsulation
	  ○ Inheritance and Polymorphism
	  ○ Exception Handling
	  ○ Abstract Data Types (wrapper, list, tree, dictionary, queue, cellar and enumeration)
	Software Engineering
	• General basics of software engineering
	• Requirements Engineering and object-oriented analysis: basic terms, phases, activities and procedures
	• OOA with the UML including use cases, activity diagrams, class diagrams, state diagrams, sequence diagrams.
	In order to increase student comprehension of course materials, excursions may be taken (companies, fairs, museums, exhibitions, conferences, events, etc.).

Teaching Method	Programming: Lecture (2 hpw), Exercise (2 hpw) Software Engineering: Lecture (2 hpw), Exercise (1 hpw)
Course / Teaching and Learning Methods	The lecture will be taught in the style of a seminar. The exercises are developed, amongst others, in teams and the solutions are preferably presented by the students.
Examination Forms	Module exam as a written exam (120 minutes: Programming 60 minutes, Software Engineering 60 minutes)).

Workload / Contact Hours / Self-Study Time	300 / 105 / 195 hours
Participation Recommendations	None.
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	5 / 210 of final grade (weighting of 0.5)
Module Use (in other courses of study)	-
Bibliography / Literature	Programming • B. W. Kernighan and D. M. Ritchie, The C programming language. Englewood Cliffs, N.J.: Prentice Hall, 1988. • B. Stroustrup and an O. M. C. Safari, A Tour of C++, Second Edition. 2018. Software Engineering • G. Booch, J. Rumbaugh, and I. Jacobson, The unified modeling language user guide, 2nd ed. Upper Saddle River, NJ: Addison-Wesley, 2005. • Sommerville, I.: Software Engineering (9. Ed.), Boston (USA): Pearson Education, 2011. • Oshana, R.: Software Engineering for Embedded Systems: Methods, Practical Techniques, and Applications (Expert Guide), Newnes, Mai 2013, ISBN: 978-0124159174.

Module Description	**Engineering Design**
Module Abbreviation	ELE-B-2-2.04
Module Coordinator	Prof. Dr. Emanuel Slaby

ECTS Points	5	**Total Workload**	150
Weekly Contact Hrs	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Study Semester / Course Frequency / Duration	2nd Semester / Summer Semester / 1 Semester

Qualification Objectives	The students will acquire competencies in the basics of engineering design • They will know the basic terms of engineering design and be able to explain them. • They will know the basic techniques of engineering design and be able to apply them. • Students will be familiar with the many possibilities that arise through design using CAD and can apply basic functions by using the techniques of design theory. The practical and theoretical skills learned will serve as the basis for prototyping.
Contents	• Construction processes • Definition of tasks, requirements and functions • Creativity techniques • Basic rules of design • Basics Human Centered Design • Drawing principles • Illustrations, sections, dimensioning • Tolerances, fits and surfaces • Materials and production methods • Early prototyping
Teaching Method	Lecture (1 hpw), Exercise (1 hpw), Practice (2 hpw)

Course / Teaching and Learning Methods	Course content in the lecture is taught using slides or pictures on the board. The applicability of the content in practice will be examined and will be explained by examples. In the exercises, lecture content will be more deeply examined by means of appropriate exercises. In doing so, the students will have the opportunity to complete the exercises on the board under moderation of the lecturer. Questions that the students may have will be discussed and answered in groups. Excursions are also possible. In the lab work, the educational content is partially taught based on slides or pictures on the board in the context. The course will be held in the PC lab rooms. The CAD software SolidWorks will be presented in a practical manner and the students will learn how to use it based on design examples.
Examination Forms	Module final examination as written exam. Course achievements in form of exercises and submission of projects.
Workload / Contact Hours / Self-Study Time	150 / 60 / 90 Hours
Participation Recommendations	None.
Prerequisite for ECTS points	Passed module final exam (90 minutes).
Significance of the module grade for the final grade	2.5/210 (weighting of 0.5)
Module Use (in other courses of study)	-
Bibliography / Literature	• Dieter, George, Schmid, Linda: Engineering Design, McGraw-Hill Education, 5th edition, 2012, ISBN-10: 0073398144. • Pahl, Gerhard; Beitz, W.: Engineering Design: A Systematic Approach, Springer; 3rd edition, 2007, ISBN-10: 1846283183. • Norman, Don: The Design of Everyday Things: Revised and Expanded Edition, Basic Books, 2nd edition, 2013, ISBN-13: 978-0465050659 • Howard, William; Musto, Joseph: Introduction to Solid Modeling Using SolidWorks, McGraw-Hill Science/Engineering/Math, 9th edition, 2013, ISBN-10: 0073522694. • Lefteri, Chris: Making it: manufacturing techniques for product design, Laurence King Pub, 2nd edition, 2012, ISBN-13: 978-1856697491. • Warnier, Verbruggen, Unfold (eds.): Printing Things: Visions and Essentials for 3D Printing, Die Gestalten Verlag, 1st edition, 2014, ISBN-13: 978-3899555165

Module Description	**Audio and Video Technologies**
Module Abbreviation	ELE-B-2-2.05
Module Coordinator	Prof. Stefan Albertz

ECTS Points	5	**Total Workload**	150
Weekly Contact Hrs	3	**Contact Hours**	45
Language	English	**Self-Study Time**	105

Study Semester / Course Frequency / Duration	2nd Semester / Summer Semester / 1 Semester

Qualification Objectives	Students will understand the classical audiovisual media technologies and their methods of image capturing, imaging and audio reproduction. They will be able to judge existing technologies and qualitatively analyze and apply new ones in order to use signal processing for prototype design.
Contents	Digital Imaging Technology • Raster Graphics • Resolutions • Formats • Standards Color • Depth Image Processing • Color Channels • Quantization • Dithering • Normalization Compositing • Mattes and Masks • Procedural Mask Generation • Pattern Tracking and Stabilization • Basic Compositing Processes A/V Media • Media Formats • Codecs • Containers

	• Distribution and Areas of Application • Digital Cameras A/V Measurement Procedures • Waveform Monitors • Vectorscopes Image Reproduction Methods • Display Technologies Basics Image Compression • Fundamentals • Chroma Subsampling • JPEG Methods • Discrete Cosine Transformation In order to increase student comprehension of course materials, excursions may be taken (companies, fairs, museums, exhibitions, conferences, events, etc.).
Teaching Method	Lecture (2 hpw), Exercise (1 hpw)
Course / Teaching and Learning Methods	The lecture will take place in the style of a seminar, supplemented by case studies, individual and group work, presentations, reflection and feedback discussion. In the Business English course this will be further supplemented by reading exercises, translating, editing and writing.
Examination Forms	Module exam as a written test (90 minutes).
Workload / Contact Hours / Self-Study Time	150 / 45 / 105 hours
Participation Recommendations	None
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	2.5/210 (weighting of 0.5)
Module Use (in other courses of study)	-
Bibliography / Literature	• Brinkmann, R. (2008): The Art and Science of Digital Compositing, Morgan Kaufmann, Elsevier Ltd., Oxford, ISBN 978-0123706386. • Poynton, C. A. (2012): Digital Video and HD: Algorithms and Interfaces, Morgan Kaufmann, ASIN B00Y2QVVLA. • Rickitt, R. (2006): Special Effects: The History and Technique, Aurum Press, ISBN 978-1845131302.

Module Description	**Electronic Engineering 3**
Module Abbreviation	ELE-B-2-3.01
Module Coordinator	Prof. Dr. Ali Hayek

ECTS Points	5	**Total Workload**	150
Weekly Contact Hrs	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Study Semester / Course Frequency / Duration	3rd Semester / Winter Semester / 1 Semester

Qualification Objectives	Students acquire skills in the fundamentals of semiconductor devices. They can analyze and calculate diodes, field effect transistors, bipolar transistors and operational amplifiers in simple circuits. They can explain basic properties of logic gates and the circuit techniques for their implementation.
Contents	• Diodes • Bipolar and field effect transistors • Operational amplifier
Teaching Method	Lecture (2 hpw), Exercise (2 hpw).
Course / Teaching and Learning Methods	The lecture will be taught in the style of a seminar. In the exercises relevant tasks will be completed and the results will be discussed.
Examination Forms	Module exam as a written test (90 minutes).
Workload / Contact Hours / Self-Study Time	150 / 60 / 90 hours
Participation Recommendations	None.
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	5 / 210 of final grade (weighting of 1)

Module Use (in other courses of study)	-
Bibliography / Literature	• R. Hambley, Electrical Engineering: Principles and Applications, 6th ed. Pearson Education, 2014. • A. S. Sedra, K. C. Smith, T. C. Carusone and V. Gaudet. Microelectronic Circuits. 8th Ed. Nov. 2019 • A. Malvino and D. Bates. Electronic Principles. 8th ed. McGraw-Hill, 2016 • M. E.Schultz, and Bernard Grob. Grob's Basic Electronics. 12th ed. McGraw-Hill, 2015. • M. E. Schultz, Problems Manual for Grob's Basic Electronics. 12th ed. McGraw-Hill, 2015. • U. Tietze, C. Schenk and E. Gamm, "Halbleiter-Schaltungstechnik," 16. Auflage, Springer, 2019 • F. Thuselt, "Physik der Halbleiterbauelemente," Springer, 2005 • K.-H. Löcherer, "Halbleiterbauelemente," Teubner, 1992

Module Description	**Engineering Mathematics 3**
Module Abbreviation	ELE-B-2-3.02
Module Coordinator	Prof. Dr. Jan Eric Kyprianidis

ECTS Points	5	**Total Workload**	150
Weekly Contact Hrs	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Study Semester / Course Frequency / Duration	3rd Semester / Winter Semester / 1 Semester

Qualification Objectives	Students acquire advanced skills in basic mathematical concepts and procedures. They can calculate partial derivatives and differential operators of vector analysis. They can calculate curve, surface and volume integrals and apply the integral theorems of Gauss and Stokes. For typical tasks in the field of technical systems they can select and apply the appropriate learned methods and interpret the results.
Contents	• Differential and integral calculus in several variables • Vector analysis
Teaching Method	Mathematical Fundamentals: Lecture (2 hpw), Exercise (2 hpw)
Course / Teaching and Learning Methods	The lecture will be taught in the style of a seminar. In the exercises relevant tasks will be completed and the results will be discussed.
Examination Forms	Module exam as a written exam (90 minutes).
Workload / Contact Hours / Self-Study Time	150 / 60 / 90 Hours
Participation Recommendations	None
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	5 / 210 of final grade (weighting of 1)

Module Use (in other courses of study)	-
Bibliography / Literature	• A. Croft et al., Engineering Mathematics, 5th ed. Pearson Education, 2017. • G. James et al., Modern Engineering Mathematics, 5th ed. Prentice Hall, 2005. • G. James et al. Advanced Modern Engineering Mathematics, 4th ed. Prentice Hall, 2011. • D.G. Zill and W.S. Wright, Advanced Engineering Mathematics, 5th ed. Jones & Bartlett Learning, 2014.

Module Description	**Microcontroller**
Module Abbreviation	ELE-B-2-3.03
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Points	10	**Total Workload**	300
Weekly Contact Hrs	6	**Contact Hours**	90
Language	English	**Self-Study Time**	210

Study Semester / Course Frequency / Duration	3rd Semester / Winter Semester / 1 Semester

Qualification Objectives	**Embedded Systems** Students will acquire basic competencies in the construction and programming of microcontrollers: • The students will know the application areas of embedded systems. • They will know the structure (core and interfaces) and the functionality of microprocessors and microcontrollers and be able to explain this and be able to select the right architecture for any given problem. • They will have practical experience with the independent development of software for embedded systems in the C and C++ programming languages. • The students will know the basic functionality of real-time operating systems. • Students will be able to independently design and test embedded systems tailored to the specific requirements of a particular country by applying the analytical and technical methods of electronics and technical computer science as well as intercultural competencies they have learned in the course. • The students know the basic functioning of computer networks. The theoretical and practical work will be a foundation for considering larger problems in the context of prototype work. In the practical part of the course, the students will work in small groups in the area of microcontroller programming, which will support the development of communication skills and agreement between students and will also increase their intercultural and social competencies.

Contents	• Representation of information in the computer • Internal structure of a microprocessor • Structure and components of a microcontroller (counter / timer, A/D converter, watchdog) • Basics of hardware-related software development for microprocessors and microcontrollers with C (data types, control structures, pointers, functions) • Function of compiler / linker / debugger, organization of large software architectures • Modeling and implementation of control algorithms using finite state machines • Special features of hardware-related software development fundamentals of real-time operating systems • Interfaces (including µC interfaces, bus systems) Basis of computer networks: ISO/OSI reference model and basic protocols
Teaching Method	Lecture (2 hpw), Exercise/Practice (2+2 hpw)
Course / Teaching and Learning Methods	In the lecture, the fundamentals will be explained, and examples will be discussed together. In the exercise and lab, the procedures will be demonstrated; tasks and projects will be completed and individual questions will be answered.
Examination Forms	Module exam as a written exam (90 minutes) as well as an additional examination within the scope of the exercises and lab work: the students will independently complete a project. This includes writing of a documentation of 5 to 7 pages and a final presentation of 10 minutes.
Workload / Contact Hours / Self-Study Time	300 / 90 / 210 hours
Participation Recommendations	None.
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	10 / 210 of final grade (weighting of 1)
Module Use (in other courses of study)	-
Bibliography / Literature	• Cady, Fredrick M.: Microcontrollers and Microcomputers: Principles of Software and Hardware Engineering, Oxford University Press, 1997. • Valvano, Jonathan W.: Embedded Systems: Introduction to Arm Cortex-M Microcontrollers, 5th Edition, CreateSpace Independent Publishing Platform, 2012, ISBN-10: 1477508996. • Zhu, Yifeng: Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C, E-Man Press LLC; 2 edition, 2015, ISBN-10: 0982692633. • Noergaard, Tammy: Embedded Systems Architecture, Second Edition: A Comprehensive Guide for Engineers and Programmers, Newnes; 2 edition, 2012, ISBN-10: 0123821967.

	• Kernighan, Brian W.; Ritchie Dennis M.: C Programming Language, Prentice Hall; 2 edition, 1988, ISBN-10: 0131103628. • Stroustrup, Bjarne: The C++ Programming Language, Addison-Wesley Professional; 4th edition, 2013, ISBN-10: 0321563840. • Stroustrup, Bjarne: Programming: Principles and Practice Using C++, Addison-Wesley Professional; 2nd edition, 2014, ISBN-10: 0321992784.

Module Description	**Interactive Systems Design 1**
Module Abbreviation	ELE-B-2-3.04
Module Coordinator	Prof. Dr. Achim Rettbergl

ECTS Points	5	**Total Workload**	150
Weekly Contact Hrs	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Study Semester / Course Frequency / Duration	3rd Semester / Winter Semester / 1 Semester

Qualification Objectives	The students will learn from a user experience to conceptualize the interaction with products, services and / or environments. They will thereby also consider the physical, intellectual and cultural environment. During the course an example design will be completed, which will allow the students to be capable of independently solving a user interaction problem.
Contents	• User-/Activity-Centered Conception and Design • Ergonomics and Psychology • Human-Computer Interaction • Conception, Design and Prototyping
Teaching Method	Lecture (2 hpw), Exercise (2 hpw)
Course / Teaching and Learning Methods	In the lecture, the fundamentals will be explained and examples will be discussed together. In the exercises, the methods will be demonstrated, exercises and projects will be completed and individual questions will be answered.
Examination Forms	Module exam as a written (90 minutes) or oral exam (20 to 25 minutes).
Workload / Contact Hours / Self-Study Time	150 / 60 / 90 Hours.
Participation Recommendations	None.
Prerequisite for ECTS points	Passed module final exam.

Significance of the module grade for the final grade	5 / 210 of final grade (weighting of 1)
Module Use (in other courses of study)	-
Bibliography / Literature	• Cameron Banga and Josh Weinhold: Essential Mobile Interaction Design: Perfecting Interface Design in Mobile Apps Apr 6, 2014. • Dan Saffer: Designing for Interaction. Creating Innovative Applications and Devices, 2009. • Jesse James Garrett: The Elements of User Experience: User-Centred Design for the Web and Beyond. Dec 26, 2010. • Marco Spies: Branded Interactions. Creating the Digital Experience. 24. Aug 2015. • Buxton, W. Sketching User Experiences, Morgan Kaufmann 2007. • Moggridge, B. Designing Interactions, MIT Press, 2006. • Saffer, D. Designing for Interaction, New Riders 2009.

Module Description	Audio and Video Processing
Module Abbreviation	ELE-B-2-3.05
Module Coordinator	Prof. Stefan Albertz

ECTS Points	5	Total Workload	150
Weekly Contact Hrs	3	Contact Hours	45
Language	English	Self-Study Time	105

Study Semester / Course Frequency / Duration	3rd Semester / Winter Semester / 1 Semester

Qualification Objectives	The students will understand image and audio signal processing, current audio and video coding methods as well as complex imaging systems. They will use existing processing methods and will be taught how to analyze new procedures, to apply them in their own projects and to further develop them.
Contents	File-Based Workflows • Transition • Distribution • Security Features Mastering & Distribution • Current Mastering Standards • Distribution Channels for A / V Media • Broadcast • Video on Demand (VoD, OTT) • Media Asset Management Digital Image Recording • Image Sensors • Bayer Pattern • Debayering • RAW Workflow A/V Measurement Procedures • Signal Level Measurement • Codec Analysis Tools

	Audio Compression • Fundamentals • Psychoacoustic Effects • MPEG Layer 3 / AAC Audio Reproduction • Frequency-Dependent Filters • Time-Dependent Filters • Object-Based Methods Video Compression • Fundamentals • Redundancy in the Moving Image • Group of Pictures Methods • Motion Estimation • MPEG-2 Method • Generation Loss Image Reproduction Methods • Display Technology (in depth) • Projectors In order to increase student comprehension of course materials, excursions may be taken (companies, fairs, museums, exhibitions, conferences, events, etc.).
Teaching Method	Lecture (2 hpw), Exercise (1 hpw)
Course / Teaching and Learning Methods	The lecture will take place in the seminar style, supplemented by case studies, individual and group work, presentations, reflection and feedback discussion.
Examination Forms	Module exam as a written test (90 minutes).
Workload / Contact Hours / Self-Study Time	150 / 45 / 105 hours
Participation Recommendations	None
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	5 / 210 of final grade (weighting of 1)
Module Use (in other courses of study)	possibly Computer Visualistics and Design
Bibliography / Literature	• Dickreiter, M., Dittel, V., Hoeg, W., Wöhr, M. (2014): Handbuch der Tonstudiotechnik - Band 1, De Gruyter, SAUR, ISBN 978-3-11-028978-7.

	• Dickreiter, M., Dittel, V., Hoeg, W., Wöhr, M. (2014): Handbuch der Tonstudiotechnik - Band 2, De Gruyter, SAUR, ISBN 978-3-11-028978-7. • Friesecke, A. (2014): Die Audio-Enzyklopädie - ein Nachschlagewerk für Tontechniker, De Gruyter, SAUR, ISBN 978-3-11-034013-6. • Poynton, C.A.(2012): Digital Video and HD: Algorithms and Interfaces, Morgan Kaufmann, ASIN B00Y2QVVLA.

Module Description	**Control Engineering**
Module Abbreviation	ELE-B-2-4.01
Module Coordinator	Prof. Dr.-Ing. João Paulo Javidi da Costa

ECTS Points	10	**Total Workload**	300
Weekly Contact Hrs	7	**Contact Hours**	105
Language	English	**Self-Study Time**	195

Study Semester / Course Frequency / Duration	4th Semester / Summer Semester / 1 Semester

Qualification Objectives	Students acquire skills in the mathematical and technical fundamentals of control engineering. They will be able to model control systems and explain the functionality of different types of controllers. They can examine control systems for stability and design controllers using MATLAB. They can calculate Fourier and Laplace transformations. For typical tasks in the field of technical systems they can select and apply the appropriate learned methods and interpret the results.
Contents	Control Engineering: • Introduction to control engineering • Design of control systems • Types of controllers • Stability • Examples and introduction to MATLAB for the design of control systems. Engineering Mathematics 4: • Fourier transformation • Laplace transformation

Teaching Method	Control Engineeering: Lecture (2 hpw), Practice (1 hpw) Engineering Mathematics 4: Lecture (2 hpw), Exercise (2 hpw)
Course / Teaching and Learning Methods	The lecture will be taught in the style of a seminar. In the exercises relevant tasks will be completed and the results will be discussed.
Examination Forms	Module exam as a written exam (90 minutes).
Workload / Contact Hours / Self-Study Time	300 / 105 / 195 hours
Participation Recommendations	None
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	10 / 210 of final grade (weighting of 1)
Module Use (in other courses of study)	-
Bibliography / Literature	• A J. Wilkie, M. Johnson and R. Katebi, Control Engineering - an Introductory Course, Palgrave Publisher, 2002 • O. Katsuhiko. Modern Control Engineering. 5th ed. Pearson, 2010. • O. Katsuhiko. MATLAB for Control Engineers. Pearson, 2008. • R.C. Dorf and R.H. Bishop. Modern Control Systems. 13th ed. Pearson, 2017. • C.C. Houpis, S.N. Sheldon: „Linear Control System Analysis and Design with Matlab, 6th Edition“, CRC Press 2013, ISBN: 9781466504264. • Croft and R. Davison, Mathematics for Engineers, 5th ed. Pearson Education, 2017. • G. James et al., Modern Engineering Mathematics, 5th ed. Prentice Hall, 2005. • G. James et al., Advanced Modern Engineering Mathematics, 4th ed. Prentice Hall, 2011. • D.G. Zill and W.S. Wright, Advanced Engineering Mathematics, 6th ed. Jones & Bartlett Learning, 2018.

Module Description	**Prototyping and Systems Engineering**
Module Abbreviation	ELE-B-2-4.02
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Points	10	**Total Workload**	300
Weekly Contact Hrs	6	**Contact Hours**	90
Language	English	**Self-Study Time**	210

Study Semester / Course Frequency / Duration	4th Semester / Summer Semester / 1 Semester

Qualification Objectives	**Prototyping** The students will acquire competencies in interdisciplinary group work: • Students will be able to apply the acquired competencies in the fields of electrical engineering, computer science and design to an interdisciplinary project. • They will gain an understanding of the interdisciplinary interaction in the conception and implementation of a complex task and, taking design parameters into account, will be able to select suitable methods and techniques from the various disciplines and apply them independently. • They will be able to write up the results in a scientific text using the principles of scientific writing. • Furthermore, students will be able to apply intercultural competencies by using the techniques discussed in the course to later develop systems in an international environment. The practical work serves as a basis for considering larger problems in the context of a thesis or project work. The interdisciplinary work in small groups strengthens the communication skills and the agreement between students. **Systems Engineering** The students will be familiar with the different levels of system engineering. This includes technical management and the path from system analysis and system design to product realization. The students will acquire knowledge about the classification of phase models and the interaction of the phases. The

	students will be able to apply UML and SysML and to use them for technical applications. They will be capable of making project plans for complex projects: • Students will be familiar with the challenges of developing systems with an interdisciplinary character. • They will know the terms, characteristics and definitions of systems and can explain phase models and the interaction of the project phases. • The students will be able to present sub-processes of system engineering and recognize the interaction between project management and system design. • They will be able to apply methods and techniques of requirement and risk management. • Students will be able to use SysML for technical applications in various project phases by using the methods and techniques of system engineering in order to design complex problems across systems. The knowledge acquired will be used in the Prototyping course. The theoretical and practical work during the course will serve as a foundation for considering larger issues within a thesis or project work and will give the students insight into the work of a systems engineer.
Contents	**Prototyping:** Students reflect and deepen the knowledge acquired at the university and apply it in an interdisciplinary application to design a prototype. The prototype is designed holistically at system level and considers the design, hardware and software of the system to be designed. (Intermediate) results are presented, considering the knowledge gained in the field of presentation techniques. **Systems Engineering:** • Characteristics and definition of systems • Modelling of Systems with the SysML • Life Cycle Models
Teaching Method	Prototyping: Practice (4 hpw) Systems Engineering: Lecture (2 hpw)
Course / Teaching and Learning Methods	Individual and group work, presentations, reflection and feedback discussions. The lecture will be taught in the style of a seminar.

Examination Forms	An additional examination within the scope of the exercises and practice: the students will independently complete a project. This includes writing a documentation in the range of 10 to 15 pages and a final presentation of 20 minutes.
Workload / Contact Hours / Self-Study Time	300 / 90 / 210 hours
Participation Recommendations	Successful participation in the basic courses electrical engineering, computer science and design
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	10 / 210 of final grade (weighting of 1)
Module Use (in other courses of study)	-
Bibliography / Literature	Fundamental literature from the various disciplines as well as from the area of Systems Engineering. Systems Engineering • T. Weilkiens, Systems Engineering with SysML/UML. 2011. • INCOSE technical board, "Systems Engineering Handbook", Version 4 INCOSE, 2015. • Friedenthal, S.; Moore, A.; Steiner, R.: A Practical Guide to SysML: The Systems Modeling Language, Morgan Kaufmann, 2nd Edition, October 2011, ISBN: 978-0123852069.

Module Description	**Interactive Systems Design 2**
Module Abbreviation	ELE-B-2-4.03
Module Coordinator	Prof. Dr.-Ing. Ali Hayekl

ECTS Points	5	**Total Workload**	150
Weekly Contact Hrs	4	**Contact Hours**	60
Language	English	**Self-Study Time**	120

Study Semester / Course Frequency / Duration	4th Semester / Summer Semester / 1 Semester

Qualification Objectives	Students will acquire an understanding of the planning and implementation of interactive systems in their entirety. They will be familiar with the entire process chain of integrated development. The students will receive extensive practical experience through project topics from the industry. They will be capable of designing prototypes with a human interface by applying the technical and creative possibilities of virtual interaction forms, such as the use of augmented reality.
Contents	• Specification, modelling and development of an interactive system • Design and sampling of the hardware • Conception and programming • System implementation in an environment
Teaching Method	Lecture (2 hpw), Exercise (2 hpw)
Course / Teaching and Learning Methods	In the lecture, the fundamentals will be explained and examples will be discussed together. In the exercises, the methods will be demonstrated, exercises and projects will be completed and individual questions will be answered.
Examination Forms	An additional examination within the scope of the exercises and lab: the students will independently complete a project. This includes writing a documentation of 7 pages and a final presentation of 15 minutes.
Workload / Contact Hours / Self-Study Time	150 / 60 / 90 Hours
Participation Recommendations	None.
Prerequisite for	Passed module final exam.

ECTS points	
Significance of the module grade for the final grade	5 / 210 of final grade (weighting of 1)
Module Use (in other courses of study)	-
Bibliography / Literature	• • Ben Coleman, Dan Goodwin: Designing UX – Prototyping. 21 March 2017 • Kathryn Mcelroy: Prototyping for Designers: Developing the Best Digital and Physical Products. 13 Jan 2017 • Steve Aukstakalnis: Practical Augmented Reality: A Guide to the Technologies, Applications and Human Factors for AR and VR. 8 Sept 2017 • Anand Morab: Virtual Reality: Beginner's Guide: An uncommon guide for Virtual Reality basics. 17 Aug 2016

Module Description	**Business Communication**
Module Abbreviation	ELE-B-2-4.04
Module Coordinator	Dr. Birte Horn

ECTS Points	5	**Total Workload**	150
Weekly Contact Hrs	3	**Contact Hours**	45
Language	English	**Self-Study Time**	105

Study Semester / Course Frequency / Duration	4th Semester / Summer Semester / 1 Semester

Qualification Objectives	Through the practical application and strengthening of general language knowledge as well as the acquisition of subject-specific technical terms, students will be able to adequately communicate and correspond in the English language during their studies and in their future careers. The focus lies on communication in specific business situations and environments. Students will also strengthen intercultural competencies that they can use in various communication scenarios by engaging with the characteristics of different cultures in their careers. Students will obtain the required knowledge to submit application documents in English and interview for a job in English.
Contents	• Subject-specific development of language skills • Basics business English and commercial technical terminology • Editing and writing their own short texts • Oral and written communication • Intercultural Skills • Job applications
Teaching Method	Seminar (3 hpw)
Course / Teaching and Learning Methods	Seminar-style teaching, lectures, case studies, individual and group work, presentations, reflection and feedback discussions.
Examination Forms	Module exam as a presentation (20 minutes) with subsequent paper (5 - 7 pages).
Workload / Contact Hours / Self-Study Time	150 / 45 / 105 hours

Participation Recommendations	None.
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	5 / 210 of final grade (weighting of 1)
Module Use (in other courses of study)	-
Bibliography / Literature	• Butzphal, Gerlinde; Maier-Fairclough, Jane: Career-Express. Business English: B2 Kursbuch mit Hör-CDs und Phrasebook. Berlin: Cornelsen, 2010. • Walker, Carolyn; English for Business Studies in Higher Education; Reading: Garnet Publishing, 2008. • Downes, Colm: Cambridge English for Job-hunting; Cambridge: CUP, 2008. • Schürmann, Klaus; Mullins; Suzanne: Die perfekte Bewerbungsmappe auf Englisch. Anschreiben, Lebenslauf und Bewerbungsformular länderspezifische Tipps. Frankfurt/Main: Eichborn, 2012. • Lewis, Richard D.; When Cultures Collide. Leading Across Cultures; Boston: Nicholas Brealey Int., 2006. • Dignen, Bob; Communicating Across Cultures; Cambridge: CUP, 2011. • Dignen, Bob und Wollmann, Peter. Leading International Projects; London: KoganPage, 2016. • Dignen, Bob with Chamberlain, James; Fifty Ways to improve your Intercultural Skills; Summertown Publishing, 2009.

Module Description	**Internship/Exchange Semester**
Module Abbreviation	ELE-B-2-5.01
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Points	30	**Total Workload**	900
Weekly Contact Hrs	-	**Contact Hours**	10
Language	English	**Self-Study Time**	890

Study Semester / Course Frequency / Duration	5th Semester / Winter Semester / 1 Semester

Qualification Objectives	**Internship:** The students will learn how to apply the knowledge and skills previously acquired in their studies and to reflect upon and evaluate the experiences gained in the practical realm. During the practical semester, the students will also become familiar with various aspects of operational decision-making processes and gain insight into informational, technical, organizational, economic and social relationships of the business operations. The students acquire career-relevant and in-depth scientific knowledge and experience. They will acquire and practice intercultural competencies and apply the knowledge obtained during their studies. **Exchange Semester:** The students will be able to use and apply knowledge and skills acquired during their studies. The focus is on promoting intercultural competence within the context of a study abroad. The modules in the area of control competencies in particular will serve as a basis. The students will obtain in-depth scientific knowledge and experience and acquire or broaden their intercultural competencies.
Contents	**Internship:** The students will choose specific tasks outside the university, which come about as a result of the practical cooperation in various business operating areas.

	Ideally, the students will belong to a team with fixed areas of responsibility. In this context, they will take on clearly defined tasks or subtasks and thus have the opportunity to grasp the importance of each task in connection with the entire operation. Place of learning: preferably an international industrial company **Exchange Semester:** The students will choose regular study courses at a foreign university and complete the related module examinations. Place of learning: University abroad
Teaching Method	Practical Component
Course / Teaching and Learning Methods	Application-Oriented Work
Examination Forms	**Internship:** Internship Report (Paper with a length of 15 to 20 pages) and subsequent oral presentation (presentation in length of 10 to 15 minutes). The internship report counts for 70% of the module grade and the presentation for 30%. **Exchange Semester:** Successfully completed exams at the foreign university according to performance agreement or examinations as described in the internship.
Workload / Contact Hours / Self-Study Time	900 / 10 / 890 hours
Participation Recommendations	None
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	30 / 210 of final grade (weighting of 1)
Module Use (in other courses of study)	-
Bibliography / Literature	Internship agreement of Hamm-Lippstadt University of Applied Sciences

Module Description	Hardware Engineering
Module Abbreviation	ELE-B-2-6.01
Module Coordinator	Prof. Dr.-Ing Ali Hayek

ECTS Points	10	Total Workload	300
Weekly Contact Hrs	7	Contact Hours	105
Language	English	Self-Study Time	195

Study Semester / Course Frequency / Duration	6th Semester / Summer Semester / 1 Semester

Qualification Objectives	**Circuit Design:** The course serves as an introduction into the basics of circuit design and the creation process of electronic printed circuit boards (PCBs). The students will learn the methods, tools and procedures to design, partition and manufacture a system-specific electronic sub-assembly in SMT technology. **Digital Technology:** The students will acquire in-depth competencies in hardware-related implementation and theoretical knowledge, in order to apply structural (HW) and behavioral (SW) design techniques for the implementation of functions: • Students will be able to explain Mealy & Moore machines, the building blocks of digital technology, VHDL language elements and HW technologies. • They will be able to explain techniques for transitioning from logic to switching algebra, differentiating the relationship between design parameters (performance, area, power consumption, costs) and switching algebra processes. • Students will be able to minimize switching functions, design sequential circuits, create simple VHDL programs, configure an FPGA device, and implement functions on their own. Students will be able to apply the acquired skills in circuit design and digital technology to a larger project. In the development of the project, intercultural requirements will be considered in addition to the technical issues. The theoretical and practical work will be a foundation for the

	consideration of larger tasks in the context of a thesis or project work. In the practical part of the course, in the area of PCB design and simulation of VHDL programs / FPGA programming, small group work will strengthen the communication skills and agreement between the students.
Contents	**Circuit Design** • Electronic Sub-Assemblies • System Specification and Circuit Design • Partitioning and Layout Design • Construction, Manufacture and Placement of PCBs • Fundamentals of Surface Mount Technology (SMT) • Design-to-Cost Considerations • Aspects of Electromagnetic Compatibility (EMC) • Design Tools and Examples **Digital Technology** • Digital Circuitry and Interface • Terms, Classes, Presentation Forms (tabular, graphical, algebraic) • Normal Forms (CNF, DNF) • Minimization (Quine-McCluskey, KV, Nelson, Petrick) • Combinatorial Logic • Sequential Logic • Syntax & Semantics of Hardware Description Language VHDL • Sequential Circuits & Automata • Building Blocks of Digital Technology • Simulation of Hardware Descriptions • Design of Digital Circuits • Design of State Machines • Hardware Design in FPGA Technology **Hardware Engineering Lab** Implementing a project based on the content of the circuit design and digital technology courses. In order to increase student comprehension of course materials, excursions may be taken (companies, fairs, museums, exhibitions, conferences, events, etc.).
Teaching Method	Circuit Design: Lecture (2 hpw) Digital Technology: Lecture (2 hpw) Lab: Practical work (3 hpw)
Course / Teaching and Learning Methods	The lecture will be taught in the style of a seminar. The basics for the continuing engineering disciplines will be taught based on current practice examples and in relation to current topics. Exercises will be integrated into the lecture. A projector and whiteboard will be available as technical aids. The exercises will be completed in teams and the solutions will be presented, preferably by the students.

Examination Forms	Module exam as a written exam (120 minutes: Circuit Design 60 minutes, Digital Technology 60 minutes) as well as an additional examination within the scope of the exercises and labs: the students will independently complete a project. This includes writing a documentation of 10 - 15 pages and a final presentation of 10 to 15 minutes.
Workload / Contact Hours / Self-Study Time	300 / 105 / 195 hours
Participation Recommendations	None
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	10 / 210 of final grade (weighting of 1)
Module Use (in other courses of study)	-
Bibliography / Literature	Circuit Design • G. Zickert, „Leiterplatten: Stromlaufplan, Layout und Fertigung“, Ein Lehrbuch für Einsteiger,“ 2. aktualisierte Auflage, Verlag: Carl Hanser Verlag GmbH & Co. KG, 2018 • S. Monk, "Make your own PCBs with Eagle", Publisher McGraw Hill, 2014 • M. Scarpino, "Designing circuit board with Eagle", Pearson, 2014 • A. Williams, "Build Your Own Printed Circuit Board," McGraw-Hill Publisher, 2004 • Association Connecting Electronics Industries: http://www.ipc.org/ Digital Technology • B. J. Lameres, "Introduction to Logic Circuits & Logic Design with VHDL,“ Springer Publisher, 2017, 1st Edition • V. A. Pedroni, "Circuit Design with VHDL," 2004, MIT P. J. • Ashenden, "The VDHL Cookbook," July 1990 Project Development – Hardware Engineering Praktikum • K. S. Rubin, "Essential scrum," Adisson-Wesley Publisher, 2013 • https://www.atlassian.com/ • https://www.epo.org/

Module Description	**Advanced Embedded Systems**
Module Abbreviation	ELE-B-2-6.02
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Points	10	**Total Workload**	300
Weekly Contact Hrs	6	**Contact Hours**	90
Language	English	**Self-Study Time**	210

Study Semester / Course Frequency / Duration	6th Semester / Summer Semester / 1 Semester

Qualification Objectives	Students will be capable of designing distributed, technical systems: • They will understand the special requirements and challenges in developing distributed systems. • They will be familiar with the principles, architectures and Mechanisms of distributed systems. • They will be familiar with approaches to developing distributed systems systematically. • They will be familiar with various industrial communication standards (e.g. from the area of transport). Students will be able to apply the acquired skills in distributed systems and industrial communication standards to a large project by using approaches and standards of distributed systems they have learned. In the development of projects, not only will technical aspects be considered but also intercultural requirements. The skills acquired will serve as the basis for the consideration of larger problems in the context of a thesis or project work. Through the consideration of intercultural requirements in the context of the practical work, the students will gain insight into the work of an engineer in an international environment.
Contents	**Distributed Systems:** • Scenarios of Distributed Systems • Foundations of Distributed Systems • Distributed Data Management • Communication in Distributed Systems • Challenges of Distributed Systems • Quality of Distributed Systems (e.g. safety and security) • Architectures

	Industrial Communication Standards: • Bus Systems in Motor Vehicles (e.g. CAN, LIN, FlexRay) • Car2X Standards (e.g. DSRC, CICAS) • Bus Systems in Automation Technology (e.g. I2C, Profibus) • Protocols from the Internet of Things area **Advanced Embedded Systems Lab:** • Implement a project based on the course content of Distributed Systems and Industrial Communication Standards In order to increase student comprehension of course materials, excursions may be taken (companies, fairs, museums, exhibitions, conferences, events, etc.).
Teaching Method	Distributed Systems: Lecture (2 hpw) Industrial Communication Standards: Seminar (1 hpw) Advanced Embedded Systems Lab: Practical work (3 hpw)
Course / Teaching and Learning Methods	The lecture will be taught in the style of a seminar. The basics for the advanced engineering disciplines will be taught based on current practice examples that relate to current topics. Exercises will be integrated into the lecture. A projector and whiteboard will be available as technical aids.
Examination Forms	Distributed Systems: written exam 60 minutes. Industrial Communication Standards: writing a paper (5 to 7 pages) and presentation (10 to 15 minutes) Advanced Embedded Systems Lab: writing a documentation of 10 - 15 pages and a final presentation of 10 - 15 minutes.
Workload / Contact Hours / Self-Study Time	300 / 90 / 210 hours
Participation Recommendations	None
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	10 / 210 of final grade (weighting of 1)
Module Use (in other courses of study)	-
Bibliography / Literature	Distributed Systems • Van Steen, Maarten; Tanenbaum, Andrew S.: Distributed Systems, CreateSpace Independent Publishing Platform; 3.01 edition, 2017, ISBN-10: 1543057381. • George Coulouris, Jean Dollimore, Tim Kindberg, Gordon Blair: Distributed Systems: Concepts and Design, Pearson, 5th edition, 2011, ISBN-10: 0132143011. • Tanenbaum, Andrew S., Van Steen, Maarten: Distributed Systems: Principles and Paradigms, CreateSpace

	Independent Publishing Platform, 2nd edition, 2016, ISBN- 10: 153028175X. • Burns, Brendan: Designing Distributed Systems: Patterns and Paradigms for Scalable, Reliable Services, O'Reilly Media, 1st edition, 2017, ISBN-10: 1491983647. Industrial Communication Standards • Zhang, Thao; Delgross, Luca: Vehicle Safety Communications: Protocols, Security, and Privacy, Wiley, 1st edition, 2012, ISBN-10: 1118132726. • Zurawski, Richard: Industrial Communication Technology Handbook, CRC Press, 2nd edition, 2014, ISBN-10: 148220732X • Additional current literature on this topic will be announced in the course.

Module Description	**Bachelor Thesis**
Module Abbreviation	ELE-B-2-7.01
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Points	12	**Total Workload**	360
Weekly Contact Hrs	-	**Contact Hours**	-
Language	English	**Self-Study Time**	360

Study Semester / Course Frequency / Duration	7th Semester / Winter Semester / 1 Semester

Qualification Objectives	The students will be able to work on and solve complex tasks independently and making full use of their engineering knowledge: • They will be able to work out interdisciplinary problems by using their understanding and knowledge of the current methods in their field to come up with their own ideas. • They will able, within a given time limit, to work out a concrete application-related and / or scientific question (also of a more complex nature) independently, comprehensively and according to scientific methods using their knowledge and the skills acquired. • Students will be able to clearly communicate the results of their bachelor thesis in a structured and scientific manner, both written and orally, to represent these results and to critically reflect upon them. Students will be able to make informed decisions based on their professional and social competencies, in order to prepare them for the responsibilities in their future careers as electronic engineers. Bachelor's graduates will have the necessary knowledge and skills to continue their education in a master's program.
Contents	In the bachelor's thesis, a scientific or application-related task related to the course of study should be completed. The bachelor's thesis can be done in both an external company as well as in scientific establishment in collaboration with HSHL or internally at the HSHL. The results of the work are to be presented in a scientific paper (written

	part, bachelor's thesis) and verbally presented and defended within a specified time frame (oral part).
Teaching Method	Independent completion of the task and accompanying scientific discussion with the supervising teacher
Course / Teaching and Learning Methods	Self-study accompanied by the supervising teacher
Examination Forms	The bachelor thesis consists of a written and an oral part. Both parts will be graded and need to be passed separately. Scope of the written part: depending on the task, 30 to 50 pages (plus any appendices, tables, results, graphs, program texts or similar items). Scope of the oral part: 15 to 20 minutes presentation plus a defense of the bachelor thesis.
Workload / Contact Hours / Self-Study Time	360 / 0 / 360 hours
Participation Recommendations	None
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	18 / 210 (weighting of 1.5)
Module Use (in other courses of study)	-
Bibliography / Literature	

Module Description	Project Work
Module Abbreviation	ELE-B-2-7.02
Module Coordinator	Prof. Dr. Achim Rettberg

ECTS Points	8	Total Workload	240
Weekly Contact Hrs	-	Contact Hours	-
Language	English	Self-Study Time	240

Study Semester / Course Frequency / Duration	7th Semester / Winter Semester / 1 Semester

Qualification Objectives	The students will be able to responsibly work out a result-oriented problem and independently perform complex, practice-relevant projects by obtaining the required information, organizing it properly and taking control of the contents and capacity of the project within a specific time frame: • Students will use the methods learned in their engineering studies. • They will gauge and analyze a task as completely as possible. • They will abstract the contents, structure the connections, show different solution possibilities and weigh them against each other. The students will work with a high degree of self-organization as well as with a broadening knowledge in the concrete application of the professional practice of an electronic engineer.
Contents	The concrete task will be a result of the practical collaboration in various operational areas. Ideally the student will be a part of a team in a company with set responsibilities, will work on clearly defined tasks or contribute to subtasks and thus get the opportunity to grasp and assess the importance of each task in connection with the entire operating process. It would be advantageous for the student to be included in structured tasks and in their execution / implementation in order to train the student's capacity to think and act as an engineer. Working areas that are appropriate for the student in the context of the project work essentially include

	the individual focus areas and general topics from the fields of electronic engineering, computer engineering and prototyping. Alternatively, a corresponding project at the university is also possible as long as it contains comparable tasks directly related to the industry. This is to be reflected and expanded upon in the accompanying focus modules, so that thereby a connection between the theoretical, methodical learning material and the application learned in the practice can be made.
Teaching Method	Project Work (7 ECTS) Engineering work under the guidance of a company supervisor and through supervision of a teacher at Hamm-Lippstadt University of Applied Sciences. Project Seminar (1 ECTS)
Course / Teaching and Learning Methods	Self-organized learning, accompanied by learning in practice.
Examination Forms	Written paper: scope (depending on task type) 20 to 35 pages of text. Oral Exam: 10 to 15 minutes presentation plus a defense.
Workload / Contact Hours / Self-Study Time	240 / 0 / 240 hours
Participation Recommendations	None
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	8 / 210 of final grade (weighting of 1)
Module Use (in other courses of study)	-
Bibliography / Literature	

Special Emphasis A

Module Description	**Autonomous Systems A**
Module Abbreviation	ELE-B-2-6.03
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Points	10	**Total Workload**	300
Weekly Contact Hrs	8	**Contact Hours**	120
Language	English	**Self-Study Time**	180

Study Semester / Course Frequency / Duration	6th Semester / Summer Semester / 1 Semester

Qualification Objectives	**Cyber-Physical Systems** The students will acquire in-depth competencies in the development of networked, technical systems: • Students will be able to explain the challenges and characteristics of cyber-physical systems. • They will be able to explain specification and modeling techniques of cyber-physical systems and decide when to use which techniques. • The students will be familiar with the various protocols for networked systems and can apply them in the application context. The students are able to design a networked technical system by using the design techniques of Cyber-Physical Systems and to refine this to a technical implementation. During the practical course, they will be able to write a scientific text based on the principles of scientific writing. The theoretical and practical work will serve as a foundation for the consideration of large problems in the context of a thesis or project work. The work in small groups in the practical part in the design and analysis of cyber-physical systems will strengthen the ability of the students to communicate and coordinate. **Intelligent Systems** The course introduces the concepts and architectures of machine pattern recognition and neural networks. Students should understand the key elements and algorithms in order to make the right application-based choices for network architecture and information processing. The applications involve information coding and preprocessing as part of the algorithm design.

Contents	**Cyber-Physical Systems** Basics and Definitions • Embedded Systems Hardware and Software • Architecture • Real-Time Operating Systems Specification and Modeling Techniques • Requirements • Communicating Finite State Machines • Data Flow Distributed Systems • Computer Networks • Bus Systems (various application domains) • Internet of Things **Intelligent Systems** • Motivation and Biological Foundations • Information Modeling • Basics of Pattern Recognition • Optimal Learning • Feed-Forward Networks • Industrial Applications **Autonomous Systems A Lab** • Based on the methods and techniques learned in Cyber Physical Systems 1 and Deep Learning 1, a project will completed in the field of autonomous systems. • Independent planning, analysis, modeling, implementation and testing of a complex application example In order to increase student comprehension of course materials, excursions may be taken (companies, fairs, museums, exhibitions, conferences, events, etc.).
Teaching Method	Cyber-Physical Systems: Seminar (2 hpw) Machine Learning: Seminar (2 hpw) Autonomous Systems A Lab: Practical work (4 hpw)
Course / Teaching and Learning Methods	Seminar-style teaching, lectures, case studies, individual and group work, presentations, reflection and feedback discussions.
Examination Forms	Cyber-Physical Systems and Intelligent Systems (each): 5 to 7 pages written paper and 10 to 15 minutes presentation. Autonomous Systems A Lab:10 to 15 minutes presentation and 10 to 15 pages written documentation.
Workload / Contact Hours / Self-Study Time	300 / 120 / 180 hours
Participation Recommendations	None.

Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	10 / 210 of final grade (weighting of 1)
Module Use (in other courses of study)	-
Bibliography / Literature	Cyber-Physical Systems • Lee, Edward A.; Seshia, Sanjit A.: Introduction to Embedded Systems: A Cyber-Physical Systems Approach, Introduction to Embedded Systems, 2nd Edition, 2016, ISBN-10: 0262533812. • Alur, Rajeev: Principles of Cyber-Physical Systems, Principles of Cyber-Physical Systems, 2015, ISBN-10: 0262029111. • Marvedel, Peter, Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems and the Internet of Things, Springer, 2017. • Van Steen, Maarten; Tanenbaum, Andrew S.: Distributed Systems, CreateSpace Independent Publishing Platform; 3.01 edition, 2017, ISBN-10: 1543057381. • George Coulouris, Jean Dollimore, Tim Kindberg, Gordon Blair: Distributed Systems: Concepts and Design, Pearson, 5th edition, 2011, ISBN-10: 0132143011. • Tanenbaum, Andrew S., Van Steen, Maarten: Distributed Systems: Principles and Paradigms, CreateSpace Independent Publishing Platform, 2nd edition, 2016, ISBN-10: 153028175X. • Burns, Brendan: Designing Distributed Systems: Patterns and Paradigms for Scalable, Reliable Services, O'Reilly Media, 1st edition, 2017, ISBN-10: 1491983647. • P. P. Angelov, Autonomous learning systems: From data streams to knowledge in real-time. • A. Cardon and M. Itmi, New autonomous systems. London, UK, s.l.: ISTE Hoboken NJ, 2016. • D. D. Guinard and V. M. Trifa, Building the web of things: With examples in Node.js and Raspberry Pi. Shelter Island, NY: Manning Publications, 2016. • C. Hughes and T. Hughes, Robot programming: A guide to controlling autonomous robots. Indianapolis, Indiana: Que, 2016. Intelligent Sytems • C. Bishop: "Pattern Recognition and Machine Learning", Springer Verlag 2006, ISBN: 978-0-387-31073-2. • C. Lau: "Neural Networks: Theoretical Foundations and Analysis", IEEE Press 1992, ISBN 10: 0879422807. • R. Schalkoff: "Pattern Recognition: Statistical, Structural and Neural Approaches", John Wiley & Sons, Inc., 1992, ISBN: 0471529745. • R. O. Duda, P. E. Hart, D. G. Stork: "Pattern Classification", 2nd edition, John Wiley & Sons, Inc., 2000, ISBN: 978-0-471-05669-0. • Goodfellow, Ian; Bengio, Yoshua; Courville, Aaron: Deep Learning (Adaptive Computation and Machine Learning), The MITt Press, 2016, ISBN-10: 0262035618. • R.Brause: "Adaptive Systeme".

	www.asa.informatik.uni-frankfurt.de/as/AdaptiveSysteme-Brause.pdf. • M. T. Hagan und H. B. Demuth: Neural Network Design. 2nd Edition.hagan.okstate.edu/NNDesign.pdf • www.deeplearningbook.org • https://developer.nvidia.com/deep-learning

Module Description	**Embedded Electronic Engineering A**
Module Abbreviation	ELE-B-2-6.04
Module Coordinator	Prof. Dr. Achim Rettberg

ECTS Points	10	**Total Workload**	300
Weekly Contact Hrs	8	**Contact Hours**	120
Language	English	**Self-Study Time**	180

Study Semester / Course Frequency / Duration	6th Semester / Summer Semester / 1 Semester

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<td>Qualification Objectives</td>
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Real-Time Systems
In many technical systems, the correctness of a result also depends on the point in time when the result was ascertained. The students will learn skills to analyze and design real-time systems:

The students will know the essential terms and definitions of real-time systems.
They will be familiar with real-time operating systems and their properties.
They will be familiar with aperiodic and periodic scheduling algorithms and will be to apply them after analyzing the application problem.
They will be familiar with the basics of worst-case execution time analysis.

Students will be able to independently design an application with consideration for real-time parameters by applying scheduling and worst-case execution time methods and techniques to implement safety-critical systems.
Hardware / Software Codesign
Students will acquire in-depth competencies in design methods of hardware / software codesign:

They will be able to explain methods of hardware / software codesign.
They will be familiar with system partitioning approaches and will be able to apply them.
Students will be familiar with system analysis approaches and can design and simulate functions in SystemC.

Students will be able to independently design and simulate rapid prototyping with reconfigurable hardware using the techniques learned in hardware / software codesign. They will be able to present
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	the results as part of the practical work in a scientific text using the principles of scientific writing. The theoretical and practical work will give students insight into the work of a hardware developer. The practical work in small groups will strengthen the communication and coordination skills of the students.
Contents	**Real-Time Systems** • Basics of Real-Time Systems • Aperiodic Scheduling Algorithms • Periodic Scheduling Algorithms • Real-Time Operating Systems and Standards • Real-Time Communication **Hardware / Software Codesign** System Partitioning • Levels of Abstraction • Cost Functions • Partitioning Methods System Simulation • System and Model • Discrete and Continuous State • Time Models • Discrete Event Simulation Syntax & Semantics of SystemC • Simulation of Hardware Descriptions • Design of Digital Circuits • Design of State Machines **Embedded Electronic Engineering A Lab** • Based on the methods and techniques learned in Telematics 1 and Hardware / Software Codesign, a project will be completed in the field of autonomous systems. • Independent planning, analysis, modeling, implementation and testing of a complex application example In order to increase student comprehension of course materials, excursions may be taken (companies, fairs, museums, exhibitions, conferences, events, etc.).
Teaching Method	Real-Time Systems: Seminar (2 hpw) Hardware / Software Codesign: Seminar (2 hpw) Electronic Engineering A Lab: Practical work (4 hpw)
Course / Teaching and Learning Methods	Seminar-style teaching, lectures, case studies, individual and group work, presentations, reflection and feedback discussions.

Examination Forms	Real-Time Systems and Hardware Software Codesign (each): 5 to 7 pages written paper and 10 to 15 minutes presentation. Embedded Electronic Engineering A Lab:10 to 15 minutes presentation and 10 to 15 pages written documentation.

Workload / Contact Hours / Self-Study Time	300 / 120 / 180 hours
Participation Recommendations	None
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	10 / 210 of final grade (weighting of 1)
Module Use (in other courses of study)	-
Bibliography / Literature	Real-Time Systems • G. C. Buttazzo, Hard real-time computing systems: Predictable scheduling algorithms and applications, 3rd ed. New York, NY: Springer, 2011. • H. Kopetz, Real-time systems: Design principles for distributed embedded applications, 2nd ed. New York: Springer US, 2011. • D. Abbott, Linux for embedded and real-time applications, 3rd ed. Oxford: Newnes, 2013. • B. Selic and S. Gérard, Modeling and analysis of real-time and embedded systems with UML and MARTE: Developing cyber-physical systems. Amsterdam: Elsevier Morgan Kaufmann, 2014. • Valentini, M. Khalgui, and O. Mosbahi, Eds., Embedded computing systems: Applications, optimization, and advanced design. Hershey, Pa: IGI Global (701 E. Chocolate Avenue Hershey Pennsylvania 17033 USA), 2013. Hardware / Software Codesign • Schaumont, Patrick: A Practical Introduction to Hardware/Software Codesign, Springer, 2nd edition, 2014, ISBN-10: 1489990607. • Harris, David; Harris, Sarah: Digital Design and Computer Architecture, Morgan Kaufmann, 2nd edition, 2014, ISBN-10: 0123944244. • Giovanni De Micheli, Rolf Ernst, and Wayne Wolf: Readings in Hardware/Software Co-Design. Morgan Kaufman, 2001. • Peter Marwedel: Embedded System Design. Springer, ISBN 978-94-007-0256-1, 2011. • Black, David C.: SystemC: From the Ground Up, Springer, 2nd edition, 2014, ISBN-10: 1489982663.

Special Emphasis B

Module Description	**Autonomous Systems B**
Module Abbreviation	ELE-B-2-7.03
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Points	10	**Total Workload**	300
Weekly Contact Hrs	8	**Contact Hours**	120
Language	English	**Self-Study Time**	180

Study Semester / Course Frequency / Duration	7th Semester / Winter Semester / 1 Semester

Qualification Objectives	**Verification and Validation of Cyber-Physical Systems** Cyber-Physical Systems are essentially distributed (technical) systems with a high degree of reliability. During the course students will acquire in-depth competencies in the reliability of software-intensive, technical systems: • Students will be able to explain the characteristics of cyber-physical systems. • They will be able to explain the challenges of reliable systems (especially security and confidentiality). • They will be able to explain modeling and analysis techniques for reliable systems and decide when to use which techniques. Students will demonstrate that applications from the area of embedded systems are reliable by using methods, techniques and tools to ensure safety, security, availability and reliability. The theoretical and practical work will serve as a foundation for the consideration of large problems in the context of a final paper or project work. The work in small groups in the practical part in the design and analysis of cyber-physical systems will strengthen the ability of the students to communicate and coordinate. **Deep Learning** The course goes into more depth on the basics of pattern recognition and machine learning. The students will learn complex concepts and algorithms for the design of feedback neural networks for detection tasks as well as simulation systems and HW architectures to provide recommendations for the efficient implementation of the training and detection algorithms in suitable hardware

Contents	**Verification and Validation of Cyber-Physical Systems** Basics and Definitions • Cyber-Physical Systems • Reliable Systems Modeling Techniques • Time-Dependent Automata • System Modeling Techniques Architectures for Reliable Systems • Fault-Tolerant Architectures • Safety-Critical Hardware Analysis Techniques • Hazard Analysis • Risk Analysis • Verification and Validation **Deep Learning** • Introduction to Neural Network Computing • Feedback Networks • Time Sequences • Genetic Algorithms • Simulation Systems, Software and Hardware Platforms for Neural Networks **Autonomous Systems B Lab** • Based on the methods and techniques learned in Cyber Physical Systems 2 and Deep Learning 2, a project will be completed in the field of autonomous systems. • Independent planning, analysis, modeling, implementation and testing of a complex application example In order to increase student comprehension of course materials, excursions may be taken (companies, fairs, museums, exhibitions, conferences, events, etc.).
Teaching Method	Verification and Validation Cyber-Physical Systems: Seminar (2 hpw) Deep Learning: Seminar (2 hpw) Autonomous Systems B Lab: Practical work (4 hpw)
Course / Teaching and Learning Methods	Seminar-style teaching, lectures, case studies, individual and group work, presentations, reflection and feedback discussions.
Examination Forms	Verification and Validation of CPS and Deep Learning (each): 5 to 7 pages written paper and 10 to 15 minutes presentation. Autonomous Systems B Lab:10 to 15 minutes presentation and 10 to 15 pages written documentation.
Workload / Contact Hours / Self-Study Time	300 / 120 / 180 hours
Participation Recommendations	None.

Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	10 / 210 of final grade (weighting of 1)
Module Use (in other courses of study)	-
Bibliography / Literature	Verification and Validation of Cyber-Physical Systems • Smith, David: Safety Critical Systems Handbook, Elsevier Science & Technology, 4th edition, 2016, ISBN-10: 0128051213. • Hobbs, Chris: Embedded Software Development for Safety-Critical Systems, Taylor & Francis Inc , 2015, ISBN-10: 1498726704. • Rierson, Leanna: Developing Safety-Critical Software: A Practical Guide for Aviation Software and DO-178C Compliance, Taylor & Francis Inc, 2013, ISBN-10: 143981368X. • Marvedel, Peter, Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems and the Internet of Things, Springer, 2017. • Storey, Neil: Safety Critical Computer Systems, Addison Wesley Pub Co Inc, 1st Edition, ISBN-10: 0201427877. Deep Learning • R.Brause: "Adaptive Systeme". • www.asa.informatik.uni-frankfurt.de/as/AdaptiveSysteme-Brause.pdf. • M. T. Hagan und H. B. Demuth: Neural Network Design. 2nd Edition. hagan.okstate.edu/NNDesign.pdf • C. Bishop: "Pattern Recognition and Machine Learning", Springer Verlag 2006, ISBN: 978-0-387-31073-2. • C. Lau: "Neural Networks: Theoretical Foundations and Analysis", IEEE Press 1992, ISBN 10: 0879422807. • R. Schalkoff: "Pattern Recognition: Statistical, Structural and Neural Approaches", John Wiley & Sons, Inc., 1992, ISBN: 0471529745. • R. O. Duda, P. E. Hart, D. G. Stork: "Pattern Classification", 2nd edition, John Wiley & Sons, Inc., 2000, ISBN: 978-0-471-05669-0. • www.deeplearningbook.org • https://developer.nvidia.com/deep-learning

Module Description	**Embedded Electronic Engineering B**
Module Abbreviation	ELE-B-2-7.04
Module Coordinator	Prof. Dr.-Ing. Ali Hayek

ECTS Points	10	**Total Workload**	300
Weekly Contact Hrs	8	**Contact Hours**	120
Language	English	**Self-Study Time**	180

Study Semester / Course Frequency / Duration	7th Semester / Winter Semester / 1 Semester

Qualification Objectives	**Advanced Hardware Engineering** The course is an advanced introduction to hardware engineering. The students learn the basic technologies and the design of complex applications in the field of hardware engineering. This includes various selected topics of VLSI design and the development of integrated circuits as well as the conception of hardware architectures for industrial applications. The students will gain industry-oriented competencies in the field of hardware system development at various design levels. They understand the structure, function, and design of digital integrated circuits (VLSI circuits) using modern IC design systems. They have the ability to design and model digital circuits for dependable systems (reliability, availability, maintainability and safety.) They understand the design and implementation flow for Field Programmable Gate Circuits (FPGAs) and Application Specific Integrated Circuits (ASIC), and are able to handle complex tools for the design, verification and validation of digital circuits. **Product Lifecycle Management (PLM)** In the course of the "Product Lifecycle Management“ seminar, the students get to know the relevant processes for he product engineering and PLM for steering and control of these processes by using the connections between product / servie engineering and the data generation based on socio technological developement- and production processes. They will be able to identify the main processes of PLM, analyse and systemize, assess and optimize them. The students will gain application-oriented PLM competencies, i.e. methodical and analytical understanding of PLM components by getting to know and apply process oriented collaboration and practical know how in the field of PLM. This will enable the students to work with the different PLM components and the collaboration in a job and even be able to optimize them.

Contents	**Advanced Hardware Engineering** • Advanced HDL constructs • VHDL design of complex digital circuits • Introduction to VLSI design (Very Large Scale Integration) • Dependability of hardware systems (reliability, availability, maintainability and safety). • Hardware architectures for industrial applications • FPGA design and synthesis • Reconfigurable systems • Design for testability • Front-end and back-end design-flow: floor planning, place and route, layout creation • EDA design tools using AMD Xilinx Vivado and Intel Altera as examples **Product Lifecycle Management** • General introduction and basic definitions. (Product Engineering Process PEP, Phases, Content) • Strategical PLM / PLM perspective (reasons for complexity and their impact, PDM-/PLM-strategies and paradigms, systematical product- and service engineering; CIM, CAQ). • Tool based PLM perspective and component view (document management, Bills of Material, versioning and Engineering Change Management (ECM), connections and dependencies between components, CAQ). • Operative PLM perspective (Requirements Engineering: Business-, Product-/ Service- and Data quality requirements; PLM-Tools and -implementation measures, Product-/Process- and Resource modelling). • Technical PLM-Perspective (User- / Sensor systems, application integration, IT- und Enterprise Architecture Management). **Embedded Electronic Engineering B Lab** • Based on the methods and techniques learned in Telematics and Product Lifecycle Management, a project will be completed in the field of autonomous systems / product engineering. • Independent planning, analysis, modeling, implementation and testing of a complex application example In order to increase student comprehension of course materials, excursions may be taken (companies, fairs, museums, exhibitions, conferences, events, etc.).
Teaching Method	Advanced Hardware Engineering: Seminar (2 hpw) Product Lifecycle Management: Seminar (2 hpw) Electronic Engineering B Lab: Practical work (4 hpw)
Course / Teaching and Learning Methods	Seminar-style teaching, lectures, case studies, individual and group work, presentations, reflection and feedback discussions.

Examination Forms	Advanced Hardware Engineering and Product Lifecycle Management (each): 5 to 7 pages written paper and 10 to 15 minutes presentation. Embedded Electronic Engineering B Lab: 60 minutes written exam as well as 10 to 15 minutes presentation and 10 to 15 pages written documentation.
Workload / Contact Hours / Self-Study Time	300 / 120 / 180 hours
Participation Recommendations	None
Prerequisite for ECTS points	Passed module final exam.
Significance of the module grade for the final grade	10 / 210 of final grade (weighting of 1)
Module Use (in other courses of study)	-
Bibliography / Literature	Advanced Hardware Engineering • Lameres, B. J., Introduction to Logic Circuits & Logic Design with VHDL, Springer Publisher, 2019, 2nd Edition, ISBN: 9783030124885 • Williams. J. M., Digital VLSI Design with Verilog: A Textbook from Silicon Valley Polytechnic Institute, Springer, 2014, 2nd Edition, ISBN: 9783319047881 • Amano, Hideharu, Principles and Structures of FPGAs, Springer, 2018, ISBN: 978-981-13-0824-6 • Ünsalan C., Tar B., Digital System Design with FPGA: Implementation Using Verilog and VHDL, McGraw-Hill Education, 2017, ISBN: 9781259837906 • Rowland, C.; Goodman, E.; Charlier, M.; et al., eds. (2015). Designing Connected Products: UX for the Consumer Internet of Things. O'Reilly Media. p. 726. ISBN 9781449372569. • Kumar A., Mangey R.,The Handbook of Reliability, Maintenance, and System Safety through Mathematical Modeling, Elsevier, 1st Edition, ISBN: 9780128195826 Product Lifecycle Management: • Eigner, Stelzer; Product Lifecycle Management: Ein Leitfaden für Product Development und Life Cycle Management, Springer, Berlin; Auflage: 2. 2009 • Arnold, V., u. a., Product Lifecycle Management beherrschen, Springer, Berlin: 2005 • Spur, G., Krause, F., Das virtuelle Produkt - Management der CAD - Technik, Carl Hanser, München/Wien: 1997 • Scheer, A.-W. Wirtschaftsinformatik: Referenzmodelle für industrielle Geschäftsprozesse. 7. Aufl., Berlin [u. a.]: Springer, 1997. • Saaksvuori, Antti, Immonen, Anselmi: Product Lifecycle Management. 3. Aufl., Berlin [u. a.]: Springer, 2008