HOCHSCHULE
HAMM-LIPPSTADT

MODULE MANUAL

BACHELOR'S STUDY PROGRAM

ELECTRONIC ENGINEERING

DEGREE: BACHELOR OF ENGINEERING

Period of validity: September 1st 2026 to August 31st 2027

Valid with the study-program examination regulations dated 2024

AND Valid with the study-program examination regulations dated 2017

!Please note the information on the distinction between the two examination regulations

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Overview

Legend: ECTS - European Credit Transfer and Accumulation System, HPW – Hours Per Week, WL – Workload, CH – Contact Hours, SST – Self-Study Time

Module Name	Module Abbreviation	Module Coordinator	ECTS Credits	HPW	WL	CH	SST
Electronic Engineering 1	ELE-B-2-1.07	Prof. Dr.-Ing. João Paulo Javidi da Costa	5	5	150	75	75
Programming 1	ELE-B-2-1.08	Prof. Dr. Martin Sonntag	5	4	150	60	90
Computer Engineering	ELE-B-2-1.09	Prof. Dr. Stefan Henkler	5	4	150	60	90
Physical Foundations	ELE-B-2-1.10	Prof. Dr. Emanuel Slaby	5	4	150	60	90
Mathematics 1	ELE-B-2-1.11	Prof. Dr. Jan Eric Kyprianidis	5	4	150	60	90
Scientific Work	ELE-B-2-1.12	Dr. Birte Horn	5	4	150	60	90
Electronic Engineering 2	ELE-B-2-2.06	Prof. Dr. Jan Eric Kyprianidis	5	5	150	75	75
Programming 2	ELE-B-2-2.07	Prof. Dr. Martin Sonntag	5	4	150	60	90
Computer Networks	ELE-B-2-2.08	Prof. Dr. Emanuel Slaby	5	4	150	60	90
Engineering Design	ELE-B-2-2.09	Prof. Dr. Emanuel Slaby	5	4	150	60	90
Mathematics 2	ELE-B-2-2.10	Prof. Dr. Jan Eric Kyprianidis	5	4	150	60	90
Audio and Video Technologies	ELE-B-2-2.11	Prof. Stefan Albertz	5	3	150	45	105
Microelectronics	ELE-B-2-3.06	Prof. Dr.-Ing. Ali Hayek	5	5	150	75	75
Software Engineering	ELE-B-2-3.07	Prof. Dr. Stefan Henkler	5	4	150	60	90
Embedded Systems	ELE-B-2-3.08	Prof. Dr. Achim Rettberg	10	7	300	105	195
Mathematics 3	ELE-B-2-3.09	Prof. Dr. Jan Eric Kyprianidis	5	4	150	60	90

Module Name	Module Abbreviation	Module Coordinator	ECTS Credits	HPW	WL	CH	SST
Audio and Video Processing	ELE-B-2-3.10	Prof. Stefan Albertz	5	3	150	45	105
Control Engineering 1	ELE-B-2-4.05	Prof. Dr.-Ing. João Paulo Javidi da Costa	5	4	150	60	90
Hardware Engineering 1	ELE-B-2-4.06	Prof. Dr.-Ing. Ali Hayek	5	4	150	60	90
Prototyping and Systems Engineering	ELE-B-2-4.07	Prof. Dr. Stefan Henkler	10	6	300	90	210
Mathematics 4	ELE-B-2-4.08	Prof. Dr. Jan Eric Kyprianidis	5	4	150	60	90
Business Communication	ELE-B-2-4.09	Dr. Birte Horn	5	3	150	45	105
Internship / Exchange Semester	ELE-B-2-5.01	Prof. Dr. Stefan Henkler	30	-	900	10	890
Control Engineering 2	ELE-B-2-6.05	Prof. Dr.-Ing. João Paulo Javidi da Costa	5	4	150	60	90
Hardware Engineering 2	ELE-B-2-6.06	Prof. Dr.-Ing. Ali Hayek	5	4	150	60	90
Project Work	ELE-B-2-6.07	Prof. Dr. Achim Rettberg	8	-	240	-	240
Autonomous Systems A	ELE-B-2-6.08	Prof. Dr. Stefan Henkler	12	8	360	120	240
Embedded Electronic Engineering A	ELE-B-2-6.09	Prof. Dr. Achim Rettberg	12	8	360	120	240
Bachelor Thesis incl. Colloquium	ELE-B-2-7.05	Prof. Dr. Stefan Henkler	15	-	450	-	450
Autonomous Systems B	ELE-B-2-7.06	Prof. Dr. Stefan Henkler	15	10	450	150	300
Embedded Electronic Engineering B	ELE-B-2-7.07	Prof. Dr.-Ing. Ali Hayek	15	10	450	150	300

Industrial Design (only Ex.R. 2017)	ELE-B-2-1.05	Prof. Dr. Stefan Henkler	5	3	150	45	105
Interactive Systems Design 1 (only Ex.R. 2017)	ELE-B-2-3.04	Prof. Dr. Achim Rettberg	5	4	150	60	90
Interactive Systems Design 2 (only Ex.R. 2017)	ELE-B-2-4.03	Prof. Dr.-Ing. Ali Hayek	5	4	150	60	120
Advanced Embedded Systems (only Ex.R. 2017)	ELE-B-2-6.02	Prof. Dr. Stefan Henkler	10	6	300	90	210

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.

Excursions

Excursions (to companies, trade shows, museums, exhibitions, conferences, events, etc.) may be included as part of a course/module to enhance students' understanding of the subject matter.

Bonus points

Bonus points may be awarded. Details will be announced at the beginning of lectures.

Weighting

The weighting will be based on the SWS ratio of the courses in the module if a module exam consists of more than one exam. Otherwise, an explicit weighting is given.

Study plan for examination regulations from 2017

Electronic Engineering (ELE)

Abschluss: Bachelor of Engineering

Modulplan | Studienverlauf

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Semester 7	Bachelor Thesis CP 12		Project Work CP 8		Special Emphasis B CP 10	
Semester 6	Hardware Engineering CP 10		Advanced Embedded Systems CP 10		Special Emphasis A CP 10	
Semester 5	Internship/Exchange Semester CP 30					
Semester 4	Control Engineering CP 10		Prototyping and Systems Engineering CP 10		Interactive Systems Design 2 CP 5	Scientific Work CP 5
Semester 3	Electronic Engineering 3 CP 5	Engineering Mathematics 3 CP 5	Microcontroller CP 10		Interactive Systems Design 1 CP 5	Audio and Video Processing CP 5
Semester 2	Electronic Engineering 2 CP 5	Engineering Mathematics 2 CP 5	Computer Science 2 CP 10		Design Engineering CP 5	Audio and Video Technologies CP 5
Semester 1	Electronic Engineering 1 CP 5	Engineering Mathematics 1 CP 5	Computer Science 1 CP 5	Physical Foundations CP 5	Industrial Design CP 5	Business Communication CP 5

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Änderungen vorbehalten/Stand 11.07.2017

Study plan for examination regulations from 2024

Electronic Engineering

Graduation: Bachelor of Engineering

Modulplan | Progress of Program

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UNIVERSITY OF APPLIED SCIENCES

Semester 7	Bachelor Thesis (incl. Colloquium) ECTS 12 + 3			Special Emphasis B ECTS 15		
Semester 6	Control Engineering 2 ECTS 5	Hardware Engineering 2 ECTS 5	Project Work ECTS 8	Special Emphasis A ECTS 12		
Semester 5	Internship / Exchange Semester ECTS 30					
Semester 4	Control Engineering 1 ECTS 5	Hardware Engineering 1 ECTS 5	Prototyping and Systems Engineering ECTS 10		Mathematics 4 ECTS 5	Business Communication ECTS 5
Semester 3	Microelectronics ECTS 5	Software Engineering ECTS 5	Embedded Systems ECTS 10		Mathematics 3 ECTS 5	Audio and Video Processing ECTS 5
Semester 2	Electronic Engineering 2 ECTS 5	Programming 2 ECTS 5	Computer Networks ECTS 5	Engineering Design ECTS 5	Mathematics 2 ECTS 5	Audio and Video Technologies ECTS 5
Semester 1	Electronic Engineering 1 ECTS 5	Programming 1 ECTS 5	Computer Engineering ECTS 5	Physical Foundations ECTS 5	Mathematics 1 ECTS 5	Scientific Work ECTS 5

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Subject to change without notice/status: 10/2024

equivalence table between the two examination regulations (2017&2024)

FPO ELE 2017	FPO ELE 2024
Electronic Engineering 1	Electronic Engineering 1
Engineering Mathematics 1	Mathematics 1
Computer Science 1	Computer Engineering
Physical Foundations	Physical Foundations
Industrial Design	no longer offered
Scientific Work	Scientific Work
Electronic Engineering 2	Electronic Engineering 2
Engineering Mathematics 2	Mathematics 2
Computer Science 2	Programming 1 and Software Engineering
Engineering Design	Engineering Design
Audio and Video Technologies	Audio and Video Technologies
Electronic Engineering 3	Microelectronics
Engineering Mathematics 3	Mathematics 4
Microcontroller	Embedded Systems
Interactive Systems Design 1	no longer offered
Audio and Video Processing	Audio and Video Processing
Control Engineering	Control Engineering 1 and Mathematics 3
Prototyping and Systems Engineering	Prototyping and Systems Engineering
Interactive Systems Design 2	no longer offered
Business Communication	Business Communication
Internship/Exchange Semester	Internship / Exchange Semester
Hardware Engineering	Hardware Engineering 1 und 2
Advanced Embedded Systems	no longer offered
Bachelor Thesis	Bachelor Thesis incl. Colloquium
Project Work	Project Work
Autonomous Systems A	Autonomous Systems A
Embedded Electronic Engineering A	Embedded Electronic Engineering A
Autonomous Systems B	Autonomous Systems B
Embedded Electronic Engineering B	Embedded Electronic Engineering B

Compulsory Modules

Module Name	**Electronic Engineering 1**
Module Abbreviation	ELE-B-2-1.07
Module Coordinator	Prof. Dr.-Ing. João Paulo Javidi da Costa

ECTS Credits	5	**Total Workload**	150
HPW	5	**Contact Hours**	75
Language	English	**Self-Study Time**	75

Semester of Study / Frequency of Offer / 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.
Content	• 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), Practical work (1 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. In the practical work experiments related to electronic circuits will be conducted.
Examination Forms	Module exam as a written exam (90 minutes) The practical work is assessed using a bonus point system. Students earn bonus points by successfully completing practical exercises and assignments during the semester. The accumulated bonus points contribute to the final module assessment. Bonus points are not required to achieve the maximum score in the final exam.
Participation Recommendations	None.
Prerequisite for the award of ECTS credits	Passed final module exam.

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

Module Name	**Programming 1**
Module Abbreviation	ELE-B-2-1.08
Module Coordinator	Prof. Dr. Martin Sonntag

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / Duration	1st Semester / Winter Semester / 1 Semester

Qualification Objectives	Students acquire the competencies necessary to implement software from a professional point of view: • Students understand basic terms, methods and concepts of programming and apply them. • They will be able to use programming languages (C and C++) and apply them. • They can analyze problems from the practice of programming by applying the methods of computer science. • Practical problems can be solved independently in the taught programming language, by applying the basics of procedural programming. 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.
Content	Basics of programming languages • Variables, strings • Data types and operators • Logic • Branching and repetitions • Functions, methods and recursion • Arrays • Memory management • File in- and output Introduction to another programming language • Basics of C++ • Standard Template Library (STL)
Teaching Method	Lecture (2 HPW), Practical work (2 HPW)

Course / Teaching and Learning Methods	The lecture will be taught in the style of a seminar. In the practical work relevant tasks will be completed and the results will be discussed.
Examination Forms	Module exam as a written exam (90 minutes) The practical work is assessed using a bonus point system. Students earn bonus points by successfully completing practical exercises and assignments during the semester. The accumulated bonus points contribute to the final module assessment. Bonus points are not required to achieve the maximum score in the final exam.
Participation Recommendations	None.
Prerequisite for the award of ECTS credits	Passed final module exam.
Bibliography/Literature	• B. W. Kernighan and D. M. Ritchie, The C programming language. Englewood Cliffs, N.J.: Prentice Hall, 1988. • B. Stroustrup and O. M. C. Safari, A Tour of C++, Second Edition. 2018. • D. Griffiths and D. Griffiths, Head first C. Beijing: O’Reilly Media, 2012. • P. Prinz and T. Crawford, C in a nutshell: the definitive reference, Second edition. Sebastopol, CA: O’Reilly Media, Inc., 2015. • P. Barry and D. Griffiths, Head first programming: [a learner’s guide to programming using the Python language]. Sebastopol, CA: O’Reilly, 2009.

Module Name	**Computer Engineering**
Module Abbreviation	ELE-B-2-1.09
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / 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. The theoretical and practical work will be a foundation for the analyzing of embedded systems and microcontrollers.
Content	Fundamentals of Computer Architecture • Processors • Memory • Interfaces Fundamentals of System Software • Memory Management • Resource Management • Processes
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).

Participation Recommendations	None.
Prerequisite for the award of ECTS credits	Passed final module exam.
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 Name	**Physical Foundations**
Module Abbreviation	ELE-B-2-1.10
Module Coordinator	Prof. Dr. Emanuel Slaby

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / 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.

Content	• 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 exam (90 minutes).
Participation Recommendations	None.
Prerequisite for the award of ECTS credits	Passed module final exam.
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 Name	**Mathematics 1**
Module Abbreviation	ELE-B-2-1.11
Module Coordinator	Prof. Dr. Jan Eric Kyprianidis

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / 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.
Content	• 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 is held in seminar style. In the exercises, practice problems are worked on and the results of practice problems are discussed.
Examination Forms	Module exam as written exam (90 minutes).
Participation Recommendations	None.
Prerequisite for the award of ECTS credits	Passed module final exam.
Bibliography / Literature	• A. Croft and R. Davison, Foundation Maths, 6th ed. Pearson Education, 2016.

	• A. Croft and R. Davison, Mathematics for Engineers, 5th ed. Pearson Education, 2017. • G. James et al., Modern Engineering Mathematics, 5th ed. Prentice Hall, 2005.

Module Name	**Scientific Work**
Module Abbreviation	ELE-B-2-1.12
Module Coordinator	Dr. Birte Horn

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / 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. • They will engage critically with GenAI for the production of academic content. • 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.
Content	• Subject-specific development of language skills • Editing and writing scientific and technical texts and articles • Critical use of GenAI in Scientific Work and Academia • 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 • 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 term paper (7-10 pages, 50%) and in-class presentations (15-20 minutes, 50%) or written exam (90 minutes, 60%) and in-class presentation (15 minutes, 40%)
Participation Recommendations	None.
Prerequisite for the award of ECTS credits	Passed module final exam.
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 Name	**Electronic Engineering 2**
Module Abbreviation	ELE-B-2-2.06
Module Coordinator	Prof. Dr. Jan Eric Kyprianidis

ECTS Credits	5	**Total Workload**	150
HPW	5	**Contact Hours**	75
Language	English	**Self-Study Time**	75

Semester of Study / Frequency of Offer / 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.
Content	• 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), Practical work (1 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. In the practical work experiments related to electronic circuits will be conducted.
Examination Forms	Module exam as a written exam (90 minutes) The practical work is assessed using a bonus point system. Students earn bonus points by successfully completing practical exercises and assignments during the semester. The accumulated bonus points contribute to the final module assessment. Bonus points are not required to achieve the maximum score in the final exam.

Participation Recommendations	No formal participation requirements. Students are recommended to have the knowledge and skills typically acquired in the following module and be able to apply them: • Electronic Engineering 1 • Mathematics 1
Prerequisite for the award of ECTS credits	Passed final module exam.
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

Module Name	**Programming 2**
Module Abbreviation	ELE-B-2-2.07
Module Coordinator	Prof. Dr. Martin Sonntag

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / Duration	2nd Semester / Summer Semester / 1 Semester

Qualification Objectives	The students are able to implement software from a professional point of view • students are able to apply advanced terms, methods and concepts of programming • they can analyze problems from the practice of programming, • more complex practical problems can be solved independently in the taught programming language (C++) by applying the basics of object-oriented programming.
Content	Basic object-oriented programming concepts • Classes and objects • Attributes and methods • Encapsulation • Inheritance and polymorphism In-depth object-oriented programming concepts • Abstract data types: Lists, trees, dictionaries, snakes, basements • Templates / Generics • Exception handling • Serialization Introduction to Graphical Programming • GUI and event processing • Simple drawing methods • Strings • Geometric objects Optional: Threads, concurrent and distributed programs • Basics of concurrent programs • Thread properties and states • Synchronization concepts

	• Network programming / distributed programming Advanced topics • e.g. current libraries, comparisons with other OO programming languages, etc.
Teaching Method	Lecture (2 hpw), Practical work (2 hpw).
Course / Teaching and Learning Methods	The lecture is held in seminar style. In practical work, the results of tasks are discussed, exercises are worked on or small projects are carried out. To deepen the lectures, excursions are possible (companies, fairs, museums, exhibitions, congresses, events, etc.).
Examination Forms	Module exam as a written exam (90 minutes) The practical work is assessed using a bonus point system. Students earn bonus points by successfully completing practical exercises and assignments during the semester. The accumulated bonus points contribute to the final module assessment. Bonus points are not required to achieve the maximum score in the final exam.
Participation Recommendations	No formal participation requirements. Students are recommended to have the knowledge and skills typically acquired in the following module and be able to apply them: • Programming 1
Prerequisite for the award of ECTS credits	Passed final module exam.
Bibliography / Literature	• 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. • D. Griffiths and D. Griffiths, Head first C. Beijing: O’Reilly Media, 2012. • P. Prinz and T. Crawford, C in a nutshell: the definitive reference, Second edition. Sebastopol, CA: O’Reilly Media, Inc., 2015. • P. Barry and D. Griffiths, Head first programming: [a learner’s guide to programming using the Python language]. Sebastopol, CA: O’Reilly, 2009.

Module Name	**Computer Networks**
Module Abbreviation	ELE-B-2-2.08
Module Coordinator	Prof. Dr. Emanuel Slaby

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / Duration	2nd Semester / Summer Semester / 1 Semester

Qualification Objectives	Students will be able to analyze the operation of computer networks by understanding the basic elements, network elements, network technologies and protocols and identifying, naming and evaluating them. They are able to design their own networks.

Content	Computer Networks
	• Technical Basics
	  ○ Bit transmission
	  ○ Methods for message transmission
	• ISO/OSI reference model
	• Ethernet
	• Basic protocols in IP-based networks
	  ○ IPv4 and IPv6
	  ○ TCP and UDP
	  ○ ARP, ICMP, DHCP and DNS
	• Internet application protocols
	  ○ HTTP, FTP and e-mail
	• Virtual networks
	• Security in computer networks

Teaching Method	Lecture (2 hpw), Exercise (2 hpw).
Course / Teaching and Learning Methods	The lectures are held in seminar style. In the exercises, tasks are worked on and the results are discussed. For a large part of the exercises, the network simulation tool FILIUS is used to create and analyze networks. The exercises take place in a PC pool equipped with the necessary software.
Examination Forms	Module exam as a written exam (90 minutes).
Participation Recommendations	None.

Prerequisite for the award of ECTS credits	Passed final module exam.
Bibliography / Literature	• S. Tanenbaum and D. Wetherall, *Computer networks*, 5th ed. Boston: Pearson Prentice Hall, 2011. • C.-H. Wu, *Introduction to computer networks and cybersecurity*. Boca Raton: CRC Press/Taylor & Francis Group, 2013. • L. L. Peterson and B. S. Davie, *Computer networks: a systems approach*, 5th ed. Amsterdam ; Boston: Morgan Kaufmann, 2012.

Module Name	**Engineering Design**
Module Abbreviation	ELE-B-2-2.09
Module Coordinator	Prof. Dr. Emanuel Slaby

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / 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.
Content	• 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), Practical work (2hpw).
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 practical 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 exam as a written exam (90 minutes) The practical work is assessed as an ungraded coursework requirement. Students are required to successfully complete all designated practical exercises and obtain the corresponding testates during the semester. Successful completion of this coursework requirement is mandatory to pass the module. The coursework requirement is assessed on a pass/fail basis and does not affect the module grade.
Participation Recommendations	None.
Prerequisite for the award of ECTS credits	Passed final module exam.
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 Name	**Mathematics 2**
Module Abbreviation	ELE-B-2-2.10
Module Coordinator	Prof. Dr. Jan Eric Kyprianidis

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / Duration	2nd Semester / Summer Semester / 1 Semester

Qualification Objectives	Students acquire further skills in basic mathematical concepts and procedures. They can calculate with vectors, matrices, and determinants. They can develop functions into their real and complex Fourier series. For typical tasks in the field of technical systems, they can select and apply the appropriate methods learned and interpret the results.
Content	• Vectors • Dot, cross, and scalar triple product • Points, lines, and planes • Vector spaces • Fourier series • Matrices • Rank and invertible matrices • Determinants • Eigenvalues and Eigenvectors • Orthogonal matrices • Diagonalization
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).
Participation Recommendations	No formal participation requirements. Students are recommended to have the knowledge and skills typically acquired in the following module and be able to apply them: • Mathematics 1

Prerequisite for the award of ECTS credits	Passed final module exam.
Bibliography / Literature	• 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 Name	**Audio and Video Technologies**
Module Abbreviation	ELE-B-2-2.11
Module Coordinator	Prof. Stefan Albertz

ECTS Credits	5	**Total Workload**	150
HPW	3	**Contact Hours**	45
Language	English	**Self-Study Time**	105

Semester of Study / Frequency of Offer / 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.
Content	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
Teaching Method	Lecture (2 hpw), Exercise (1 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).
Participation Recommendations	None.
Prerequisite for the award of ECTS credits	Passed final module exam.
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 Name	**Microelectronics**
Module Abbreviation	ELE-B-2-3.06
Module Coordinator	Prof. Dr.-Ing. Ali Hayek

ECTS Credits	5	**Total Workload**	150
HPW	5	**Contact Hours**	75
Language	English	**Self-Study Time**	75

Semester of Study / Frequency of Offer / Duration	3rd Semester / Winter Semester / 1 Semester

Qualification Objectives	The course provides students with fundamental knowledge and practical skills in microelectronics, focusing on semiconductor devices and their applications in electronic circuits. After successful completion of the course, students will be able to: • explain the principles and characteristics of semiconductor devices, including diodes, bipolar junction transistors (BJTs), field-effect transistors (FETs), and operational amplifiers (op-amps). • analyze and calculate the behavior of these devices in simple circuits, including biasing, small-signal operation, and transfer characteristics. • design and evaluate basic analog and digital circuits using semiconductor components, including applications such as logic gates, amplifiers, and switching circuits. • apply theoretical knowledge to practical problems, performing calculations, simulations, and hands-on experiments with semiconductor devices. • select appropriate components and circuit topologies to meet functional and performance requirements in small-scale electronic applications
Content	• Semiconductor physics and device fundamentals: Atomic structure, energy bands, charge carriers, doping, and p-n junction behavior. • Diodes: Characteristics, biasing, rectification, and practical applications in circuits. • Bipolar junction transistors (BJTs): Operating regions, biasing techniques, small-signal modeling, and circuit applications. • Field-effect transistors (FETs and MOSFETs): Device operation, characteristics, and basic circuit applications.

	• Operational amplifiers (op-amps): Ideal and real characteristics, basic linear circuits (inverting, non-inverting, integrators, differentiators). • Basic analog circuit design: Amplifiers, voltage followers, filters, and simple signal processing circuits. • Digital logic basics: Implementation of simple logic gates and combinational circuits using discrete devices. • Circuit analysis and calculation methods: DC and AC analysis, small-signal approximations, and transfer function calculations. • Hands-on laboratory exercises: Building, testing, and measuring semiconductor-based circuits to reinforce theoretical concepts. • Use of simulation and design tools: Basic circuit simulation to verify designs before hardware implementation.
Teaching Method	Lecture (2 hpw), Exercise (2 hpw), Practical work (1 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. In the practical work experiments related to microelectronic circuits will be conducted.
Examination Forms	Module exam as a written exam (90 minutes) The practical work is assessed using a bonus point system. Students earn bonus points by successfully completing practical exercises and assignments during the semester. The accumulated bonus points contribute to the final module assessment. Bonus points are not required to achieve the maximum score in the final exam.
Participation Recommendations	No formal participation requirements. Students are recommended to have the knowledge and skills typically acquired in the following module and be able to apply them: • Electronic Engineering 1 • Electronic Engineering 2
Prerequisite for the award of ECTS credits	Passed final module exam.
Bibliography / Literature	• R. Hambley, Electrical Engineering: Principles and Applications, 6th Edition, Pearson Education, 2014. • A. S. Sedra, K. C. Smith, T. C. Carusone and V. Gaudet, Microelectronic Circuits. 8th Edition, 2019 • D. A. Neamen, Semiconductor Physics and Devices: Basic Principles, Third Edition, McGraw-Hill, 2003 • A. Malvino and D. Bates, Electronic Principles, 8th Edition, McGraw-Hill, 2016 • M. E.Schultz, and B. Grob, Grob’s Basic Electronics. 12th ed. McGraw-Hill, 2015. • P.Y. Yu and M. Cardona, Fundamentals of Semiconductors: Physics and Materials Properties, Third edition, 2010

	• S. M. Sze, M. Lee, Semiconductor Devices: Physics and Technology, 3rd Edition, Wiley, 2012

Module Name	**Software Engineering**
Module Abbreviation	ELE-B-2-3.07
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / Duration	3rd Semester / Winter Semester / 1 Semester

Qualification Objectives	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) and Object-Oriented Design (OOD). • 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.
Content	• General basics of software engineering • Requirements Engineering and object-oriented analysis: basic terms, phases, activities and procedures • OOA and OOD with the UML including use cases, activity diagrams, class diagrams, state diagrams, sequence diagrams.
Teaching Method	Lecture (2 hpw), Practical work (2 hpw).
Course / Teaching and Learning Methods	The lecture will be taught in the style of a seminar. In the practical work, there are exercises, that are developed, amongst others, in teams and the solutions are preferably presented by the students

Examination Forms	Module exam as a written exam (90 minutes). 70% The practical work of the module consists of practical assignments and a project work. Students complete hands-on tasks during the semester and develop a project related to the module topics. The assessment is based on the successful completion of the assignments, the project implementation, the submitted project documentation, and the oral presentation of the project results. The practical component contributes 30% of the finale module grade.
Participation Recommendations	No formal participation requirements. Students are recommended to have the knowledge and skills typically acquired in the following module and be able to apply them: • Programming 1 • Programming 2
Prerequisite for the award of ECTS credits	Passed final module exam.
Bibliography / Literature	• 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 Name	**Embedded Systems**
Module Abbreviation	ELE-B-2-3.08
Module Coordinator	Prof. Dr. Achim Rettberg

ECTS Credits	10	**Total Workload**	300
HPW	7	**Contact Hours**	105
Language	English	**Self-Study Time**	195

Semester of Study / Frequency of Offer / Duration	3rd Semester / Winter Semester / 1 Semester

Qualification Objectives	Students will acquire basic competencies in the construction and programming of embedded systems: • 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 they will be able to explain this and they will be able to select the right architecture for any given problem. • They will have practical experience with the 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 design and test embedded systems by applying the analytical and technical methods of electronics and technical computer science as well as intercultural competencies they have learned in the bachelor course. • The students know the basic functioning of embedded 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.
Content	• 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) • 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)
Teaching Method	Lecture (2 hpw), Exercise (2 hpw), Practical work (3 hpw).
Course / Teaching and Learning Methods	In the lecture, the fundamentals will be explained, and examples will be discussed together. In the exercise and practical work, 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). 70% The practical work of the module consists of practical assignments and a project work. Students complete hands-on tasks during the semester and develop a project related to the module topics. The assessment is based on the successful completion of the assignments, the project implementation, the submitted project documentation, and the oral presentation of the project results. The practical component contributes 30% of the finale module grade.
Participation Recommendations	No formal participation requirements. Students are recommended to have the knowledge and skills typically acquired in the following module and be able to apply them: • Programming 1 • Programming 2
Prerequisite for the award of ECTS credits	Passed final module exam.
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 Name	**Mathematics 3**
Module Abbreviation	ELE-B-2-3.09
Module Coordinator	Prof. Dr. Jan Eric Kyprianidis

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / Duration	3rd Semester / Winter Semester / 1 Semester

Qualification Objectives	Students acquire advanced skills in basic mathematical concepts and procedures. They can solve linear differential equations and calculate Fourier and Laplace and transformations. They can solve basic problems of probability and statistics. For typical tasks in the field of technical systems they can select and apply the appropriate learned methods and interpret the results.
Content	• Linear differential equations • Fourier Transform • Laplace Transform • Probability and statistics
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).
Participation Recommendations	No formal participation requirements. Students are recommended to have the knowledge and skills typically acquired in the following module and be able to apply them: • Mathematics 1 • Mathematics 2
Prerequisite for the award of ECTS credits	Passed final module exam.
Bibliography / Literature	• 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 Name	**Audio and Video Processing**
Module Abbreviation	ELE-B-2-3.10
Module Coordinator	Prof. Stefan Albertz

ECTS Credits	5	**Total Workload**	150
HPW	3	**Contact Hours**	45
Language	English	**Self-Study Time**	105

Semester of Study / Frequency of Offer / 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.
Content	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
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 exam (90).
Participation Recommendations	No formal participation requirements. Students are recommended to have the knowledge and skills typically acquired in the following module and be able to apply them: • Audio and Video Technologies
Prerequisite for the award of ECTS credits	Passed final module exam.
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 Name	**Control Engineering 1**
Module Abbreviation	ELE-B-2-4.05
Module Coordinator	Prof. Dr.-Ing. João Paulo Javidi da Costa

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / Duration	4th Semester / Summer Semester / 1 Semester

Qualification Objectives	Students acquire basic skills in the technical fundamentals of control engineering. They will be able to model control systems and explain the functionality of different types of PID controllers. They can examine control systems for stability and design controllers using MATLAB. For typical tasks in the field of technical systems they can select and apply the appropriate learned methods and interpret the results.
Content	• Introduction to control engineering • Design of control systems • Types of PID controllers • Stability • Examples and introduction to MATLAB for the design of control systems.
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).
Participation Recommendations	No formal participation requirements. Students are recommended to have the knowledge and skills typically acquired in the following module and be able to apply them: • Mathematics 3
Prerequisite for the award of ECTS credits	Passed final module exam.
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 Name	**Hardware Engineering 1**
Module Abbreviation	ELE-B-2-4.06
Module Coordinator	Prof. Dr.-Ing. Ali Hayek

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / Duration	4th Semester / Summer Semester / 1 Semester

Qualification Objectives	The course introduces the principles of the hardware engineering design process and provides an overview of circuit design as well as the methods and techniques used in the development of electronic hardware systems. In addition, the course covers the fundamentals of printed circuit board (PCB) design and the practical workflow from circuit conception to hardware prototyping and PCB manufacturing. After successful completion of the course, students will be able to: • explain the typical hardware development process and distinguish between different types of electronic components used in modern hardware systems. • select suitable electronic components and develop circuit concepts for application-oriented hardware prototypes using microcontrollers, integrated circuits (ICs), and other electronic components. • design and implement electronic circuits using modern computer-aided design (CAD) tools for schematic capture, circuit simulation, and PCB layout. • develop and document hardware prototypes by applying practical design methods and engineering workflows commonly used in industrial hardware development. • apply the fundamental methods, tools, and procedures required to design, partition, and realize system-specific electronic assemblies and understand the basic principles of PCB manufacturing and surface-mount technology (SMT).
Content	• Hardware design flow: Overview of the complete hardware development process from requirements analysis to functional prototypes. • Electronic hardware components: Characteristics, classification, and selection of microcontrollers, integrated circuits (ICs), passive components, and sensors for practical hardware applications.

	• System specification: Translating functional requirements into detailed specifications for electronic systems. • Circuit design: Schematic design, simulation, and verification of electronic circuits for prototype development. • Partitioning and layout design: Structuring electronic systems into sub-circuits, and planning PCB layouts for optimal performance and manufacturability. • Electronic assembly: Techniques for assembling and connecting components, including both through-hole and surface-mount technology (SMT). • Construction and manufacturing of PCBs: Practical workflow from PCB design to fabrication, including board materials, layer stacking, and production considerations. • Fundamentals of Surface Mount Technology (SMT): Design rules, component placement, soldering methods, and quality considerations. • Design-to-Cost considerations: Evaluating design decisions in terms of cost-efficiency while maintaining functional and performance requirements. • Aspects of Electromagnetic Compatibility (EMC): Basic principles and design measures to minimize interference and ensure regulatory compliance. • Design tools and examples: Hands-on experience with modern computer-aided design (CAD/EDA) tools for schematic capture, PCB layout, and simulation, supported by practical examples.
Teaching Method	Lecture (2 hpw), Practical work (2 hpw).
Course / Teaching and Learning Methods	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 practical work part will be implemented based on the content of the lecture.
Examination Forms	Module exam as a written exam (90 minutes). 70% The practical work of the module consists of practical assignments and a project work. Students complete hands-on tasks during the semester and develop a project related to the module topics. The assessment is based on the successful completion of the assignments, the project implementation, the submitted project documentation, and the oral presentation of the project results. The practical component contributes 30% of the finale module grade.
Participation Recommendations	No formal participation requirements. Students are recommended to have the knowledge and skills typically acquired in the following module and be able to apply them: • Electronic Engineering 1 • Electronic Engineering 2 • Microelectronics

Prerequisite for the award of ECTS credits	Passed final module exam.
Bibliography / Literature	• C. F. Coombs (Ed.), Printed Circuits Handbook, McGraw-Hill, 2007 • E. Bogatin, Signal and Power Integrity – Simplified, Prentice Hall, 2018 • H. W. Johnson, M. Graham, High-Speed Digital Design: A Handbook of Black Magic, Prentice Hall, 1993 • B. Archambeault, PCB Design for Real-World EMI Control, Springer, 2002 • M. D. Smith, Practical PCB Design, No Starch Press, 2026 • P. Scherz and S. Monk, Practical Electronics for Inventors, 4th Edition, McGraw-Hill Education Ltd, 2016 • A. Williams, Build Your Own Printed Circuit Board, McGraw-Hill Publisher, 2004

Module Name	**Prototyping and Systems Engineering**
Module Abbreviation	ELE-B-2-4.07
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Credits	10	**Total Workload**	300
HPW	6	**Contact Hours**	90
Language	English	**Self-Study Time**	210

Semester of Study / Frequency of Offer / 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.
Content	**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 (e.g. SysML) • Life Cycle Models
Teaching Method	Prototyping: Practical work (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	Examination within the scope of the practice: The students will independently complete a project. This includes writing a documentation in the range of 10 to 15 pages (40%) and a final presentation of 20 minutes (60%).
Participation Recommendations	No formal participation requirements. Students are recommended to have the knowledge and skills in the basic courses of electrical engineering, programming and mathematics and be able to apply them.
Prerequisite for the award of ECTS credits	Passed final module exam.

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 Name	**Mathematics 4**
Module Abbreviation	ELE-B-2-4.08
Module Coordinator	Prof. Dr. Jan Eric Kyprianidis

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / Duration	4th Semester / Summer 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.
Content	• Vector functions • Motion on a curve, curvature, and acceleration • Partial derivatives • Directional derivative, gradient, total derivative • Curl and divergence • Line integrals and independence of the path • Double integrals and Green’s theorem • Surface integrals and Stokes’ theorem • Triple integrals and divergence theorem • Change of variables in multiple integrals
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. Moreover, experiments related to electric circuits will be conducted.
Examination Forms	Module exam as a written exam (90 min).
Participation Recommendations	No formal participation requirements. Students are recommended to have the knowledge and skills typically acquired in the following module and be able to apply them: • Mathematics 1 • Mathematics 2

	• Mathematics 3
Prerequisite for the award of ECTS credits	Passed final module exam.
Bibliography / Literature	• 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 Name	**Business Communication**
Module Abbreviation	ELE-B-2-4.09
Module Coordinator	Dr. Birte Horn

ECTS Credits	5	**Total Workload**	150
HPW	3	**Contact Hours**	45
Language	English	**Self-Study Time**	105

Semester of Study / Frequency of Offer / 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.
Content	• Subject-specific development of language skills • Basics business English and commercial technical terminology • Critical engagement with GenAI for subject-specific performance and production • Editing and writing their own short texts • Oral and written communication • Intercultural Skills • Job applications • Review academic writing
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, 40%) with subsequent paper (5 - 7 pages, 30%); short academic essay (c. 3 pages, 30%).
Participation Recommendations	None.

Prerequisite for the award of ECTS credits	Passed final module exam.
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 Name	**Internship / Exchange Semester**
Module Abbreviation	ELE-B-2-5.01
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Credits	30	**Total Workload**	900
HPW	-	**Contact Hours**	10
Language	English	**Self-Study Time**	890

Semester of Study / Frequency of Offer / Duration	5th Semester / Winter Semester / 1 Semester

Qualification Objectives	This module enables students to apply the skills they have acquired so far and, in addition, to orient themselves for the further course of their studies. The acquisition of the following skills is to be promoted: • intercultural competencies • instrumental competences by applying the acquired knowledge in professional practice • acquisition of professional experience • professional field orientation • deepening of scientific qualifications • self-reflection • Impulses for further studies The focus can be optionally on a deepening of the acquired knowledge in the concrete application in professional practice and/or in the promotion of intercultural competence through a stay abroad. The modules in the area of soft-skills form the basis for this.
Content	**Internship in the domestic industrial company:** • Students choose specific tasks outside the university, which are characterized by the practical cooperation in various operational areas result. • Ideally, students belong to a team with a fixed area of responsibility. Within this framework, they take on clearly defined tasks or subtasks and are thus given the opportunity to classify the significance of the individual tasks in the context of the overall operations. • Support from a supervisor from the university • Learning location: company, business enterprise, research institute, university, public authority, association, etc. **University semester or internship in an industrial company abroad:**

	• The contents of the internship at an industrial company abroad are comparable to those in Germany. • In addition, the deepening of the intercultural competence is an additional focus. • If a university semester is spent abroad, the completion of defined study elements is a main focus. • Support by a supervisor of the university • Learning location: university, company, business enterprise, research institute, public authority, association, etc. abroad
Teaching Method	Application oriented work
Course / Teaching and Learning Methods	Application oriented Work
Examination Forms	Module final examination as practical report (10 to 15 pages, 80%) and a presentation (10 to 15 minutes, 20%) or the proof of passed examinations at the foreign cooperation university*. * is defined in the Learning Agreement.
Participation Recommendations	Students are recommended to have successfully completed at least 80% of the modules scheduled for the preceding semesters according to the curriculum. Further details should be discussed with the academic supervisor.
Prerequisite for the award of ECTS credits	Passed final module exam.
Bibliography / Literature	Internship agreement of Hamm-Lippstadt University of Applied Sciences and bibliography from module scientific work.

Module Name	**Control Engineering 2**
Module Abbreviation	ELE-B-2-6.05
Module Coordinator	Prof. Dr.-Ing. João Paulo Javidi da Costa

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / Duration	6th Semester / Summer Semester / 1 Semester

Qualification Objectives	Students acquire advanced skills in the technical fundamentals of control engineering. They will be able to model control systems in state space. They can linearize nonlinear state variable model and design state variable controller structures using MATLAB. For typical tasks in the field of technical systems they can select and apply the appropriate learned methods and interpret the results.
Content	• Root Locus analysis • Controller design using the Bode plot • Nichols chart • PID controller tuning methods • State variable • Linearization of nonlinear systems • Control systems design in state space
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).
Participation Recommendations	No formal participation requirements. Students are recommended to have the knowledge and skills typically acquired in the following module and be able to apply them: • Control Engineering 1
Prerequisite for the award of ECTS credits	Passed final module exam.

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 Name	**Hardware Engineering 2**
Module Abbreviation	ELE-B-2-6.06
Module Coordinator	Prof. Dr.-Ing. Ali Hayek

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / Duration	6th Semester / Summer Semester / 1 Semester

Qualification Objectives	The course focuses on the hardware design of digital circuits, with an emphasis on VHDL-based design and FPGA implementation. Students will acquire in-depth competencies in both hardware-related implementation and the theoretical foundations necessary to apply structural and behavioral design techniques for digital system functions. After successful completion of the course, students will be able to: • explain techniques for transitioning from logic design to switching algebra, and analyze the relationships between design parameters such as performance, area, power consumption, and cost in the context of switching algebra and digital design processes. • describe the structure and operation of digital combinational and sequential circuits, including Arithmetic Logic Units (ALUs) and Mealy & Moore machines, as well as fundamental building blocks of digital technology, VHDL language elements, and relevant hardware technologies. • minimize switching functions, design sequential circuits, develop VHDL programs, configure FPGA devices, and implement digital functions independently. apply their acquired skills in digital hardware design to practical FPGA-based projects, taking into account not only technical requirements but also intercultural and collaborative aspects in project development. • integrate design, simulation, and verification workflows for digital circuits using modern CAD/EDA tools, ensuring that implemented solutions meet functional, performance, and design constraints.
Content	• Digital design principles: Overview of combinational and sequential digital circuits, logic minimization, and performance/cost trade-offs.

	• Switching algebra and logic optimization: Techniques for analyzing and simplifying digital logic to optimize area, speed, and power. • Combinational and sequential circuit design: ALUs, counters, registers, finite state machines (Mealy and Moore), and other building blocks of digital systems. • VHDL fundamentals: Language elements, syntax, structural and behavioral modeling, modular design practices. • VHDL simulation and verification: Testbench creation, simulation workflows, functional verification, and debugging techniques. • FPGA architecture and configuration: FPGA structure, configuration methods, I/O standards, and on-chip resources. • Implementation of digital systems on FPGAs: Synthesis, placement, routing, and timing analysis. • Project-based FPGA design: Hands-on exercises including digital system implementation, hardware debugging, and functional verification. • Design considerations for performance and resource usage: Trade-offs between area, speed, and power in real FPGA implementations. Collaborative and interdisciplinary aspects: Teamwork, documentation, and consideration of intercultural and practical constraints in project-based hardware development. • Use of professional EDA/CAD tools: Modern tools for VHDL coding, simulation, synthesis, and FPGA configuration.
Teaching Method	Lecture (2 HPW), Practical work (2 HPW).
Course / Teaching and Learning Methods	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 practical work part will be implemented based on the content of the lecture.
Examination Forms	Module exam as a written exam (90 minutes). 70% The practical work of the module consists of practical assignments and a project work. Students complete hands-on tasks during the semester and develop a project related to the module topics. The assessment is based on the successful completion of the assignments, the project implementation, the submitted project documentation, and the oral presentation of the project results. The practical component contributes 30% of the finale module grade.
Participation Recommendations	No formal participation requirements. Students are recommended to have the knowledge and skills typically acquired in the following module and be able to apply them: • Computer Engineering • Microelectronics

	• Hardware Engineering 1
Prerequisite for the award of ECTS credits	Passed final module exam.
Bibliography / Literature	• B. J. Lameres, "Introduction to Logic Circuits & Logic Design with VHDL, 2d Edition, Springer Publisher, 2019 • V. A. Pedroni, "Circuit Design with VHDL, MIT Press, 2004. • P. J. Ashenden, "The VDHL Cookbook," First Edition, 1990 • R. E. Haskell and D. M. Hanna, Digital Design Using Digilent FPGA Boards: VHDL / Vivado Edition, LBE Books, 2019 • D. M. Harris and S. L. Harris, Dgital design and computer architecture, 2nd Edition, Morgan Kaufmann, 2013 • V. Taraate, Logic Synthesis and SOC Prototyping: RTL Design using VHDL, 1st Edition, Springer, 2020

Module Name	**Project Work**
Module Abbreviation	ELE-B-2-6.07
Module Coordinator	Prof. Dr. Achim Rettberg

ECTS Credits	8	**Total Workload**	240
HPW	-	**Contact Hours**	-
Language	English	**Self-Study Time**	240

Semester of Study / Frequency of Offer / Duration	6th Semester / Summer Semester / 1 Semester

Qualification Objectives	Students are able to apply the knowledge they have gained up to now in the course of their studies in concrete applications, e.g. professional practice. The students can use the concepts and methods learned to independently analyze a task, abstract its contents, structure the contexts and find and develop different solutions in the domain of electronic systems (e.g. hardware and/or software). The students are able to integrate the individual tasks, e.g. within a company, in superordinate objective and organizational contexts.
Content	Implementation of a project, which consists of the processing of a theoretical or practical task, with the aim of solving practical problems using scientific methods.
Teaching Method	Project engineering.
Course / Teaching and Learning Methods	Working on a project with supporting professional discussion with the supervising professor. Self-organized learning, individual or work.
Examination Forms	Module final examination as a project work, including a scientific paper (15 - 30 pages, 80%) and a presentation (10 - 15 minutes, 20%).
Participation Recommendations	None.
Prerequisite for the award of ECTS credits	Passed final module exam.
Bibliography / Literature	Subject-specific, independent literature research with the support by the supervisor.

Module Name	**Bachelor Thesis incl. Colloquium**
Module Abbreviation	ELE-B-2-7.05
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Credits	15	**Total Workload**	450
HPW	-	**Contact Hours**	-
Language	English	**Self-Study Time**	450

Semester of Study / Frequency of Offer / Duration	7th Semester / Winter Semester / 1 Semester

Qualification Objectives	Students will be able to independently solve a complex task of their subject area independently with the help of scientific methods, solve this task within a given time frame and evaluate this solution. They are able to evaluate the state of the art and research, solution concepts, technical concepts, systems and setups, design drafts, developed hardware and software, achieved results, possible extensions and evaluations in a scientific way. They can present the results in a scientific written and oral form.
Content	Processing of a theoretical or practical task / research challenge to solve problems with the help of scientific methods.
Teaching Method	Bachelor thesis including bachelor seminar
Course / Teaching and Learning Methods	Bachelor's thesis: Independent work and discussions with supervising Professor. Bachelor seminar: Presentation and discussion. Self-organized learning, individual or group work.
Examination Forms	Module final examination as written part (bachelor thesis, guideline: 30 to 60 pages, 80%) and oral part (Bachelor seminar, 20 to 30 minutes presentation and oral examination, 20%). In individual cases, the standard values may be deviated from. Proportion of the examination performance in the overall grade: • Bachelor thesis: 4/5 (12 ECTS points) • Bachelor seminar: 1/5 (3 ECTS points)
Participation Recommendations	None.

Prerequisite for the award of ECTS credits	Passed final module exam.
Bibliography / Literature	Subject-specific, independent literature research with the support by the supervisor.

Special Emphasis A

Module Name	**Autonomous Systems A**
Module Abbreviation	ELE-B-2-6.08
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Credits	12	**Total Workload**	360
HPW	8	**Contact Hours**	120
Language	English	**Self-Study Time**	240

Semester of Study / Frequency of Offer / 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. **Machine Learning** The students will acquire in-depth competencies in the application of machine learning algorithms. • Students will be able to explain the challenges and characteristics of machine learning. • Students will be able to explain the different types of machine learning algorithms including their characteristics. • Students can apply machine learning algorithms in a given context in an application-specific manner. The application involves information coding and preprocessing as part of the algorithm. **Autonomous Systems A Lab** The students will be able to apply the concepts and methods of the courses Cyber-physical Systems and Machine Learning in a systematic and combined way to solve a given problem. 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.
Content	**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 **Machine Learning** • Motivation and Biological Foundations • Information Modeling • Basics of decision trees, classification, and clustering • Optimal Learning • Feed-Forward Networks • Industrial Applications **Autonomous Systems A Lab** • Based on the methods and techniques learned in Cyber Physical Systems and Machine Learning, a project will be completed in the field of autonomous systems. • Independent planning, analysis, modeling, implementation and testing of a complex application example
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	Module exam as a presentation (15 - 20 minutes, 2 times 5%) with subsequent paper (5 - 7 pages, 2 times 20%) for each seminar (seminars at all 50%) and examinations in the context of the practical work: the students will independently complete a project. This includes writing a documentation of 2 to 5 pages (25%) and a final presentation of 10 to 15 minutes (25%).
Participation Recommendations	None.

Prerequisite for the award of ECTS credits	Passed final module exam.
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. • 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. Machine Learning • 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. • 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 Name	**Embedded Electronic Engineering A**
Module Abbreviation	ELE-B-2-6.09
Module Coordinator	Prof. Dr. Achim Rettberg

ECTS Credits	12	**Total Workload**	360
HPW	8	**Contact Hours**	120
Language	English	**Self-Study Time**	240

Semester of Study / Frequency of Offer / Duration	6th Semester / Summer Semester / 1 Semester

Qualification Objectives	**Real-Time Systems** In many technical systems, the correctness of a result also depends on the point in time when the result was computed. 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. **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 VHDL or SystemC. **Embedded Electronic Engineering A Lab** Students will be able to independently design an application with consideration for real-time parameters and hardware / software codesign characteristics by applying scheduling and worst-case execution time methods and techniques to implement safety-critical systems. They will be able to present the results as part of the practical work in a scientific paper 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.
Content	**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 and Semantics of Hardware Description Languages • 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 Real-Time Systems and Hardware / Software Codesign, a project will be completed in the field of embedded systems. • Independent planning, analysis, modeling, implementation and testing of a complex application example
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	Module exam as a presentation (15 - 20 minutes, 2 times 10%) with subsequent paper (5 - 7 pages, 2 times 15%) for each seminar (seminars at all 50%) and examinations in the context of the practical work : the students will independently complete a project. This includes writing a documentation of 2 to 5 pages (25%) and a final presentation of 10 to 15 minutes (25%).
Participation Recommendations	None.

Prerequisite for the award of ECTS credits	Passed final module exam.
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 Name	**Autonomous Systems B**
Module Abbreviation	ELE-B-2-7.06
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Credits	15	**Total Workload**	450
HPW	10	**Contact Hours**	150
Language	English	**Self-Study Time**	300

Semester of Study / Frequency of Offer / 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. **Deep Learning** The course deepens the fundamentals of pattern recognition and machine learning. Students learn complex concepts and algorithms for the design of feedback neural networks for recognition tasks as well as simulation systems and hardware architectures in order to derive recommendations for the appropriate application of deep learning algorithms. **Distributed Systems** 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. **Autonomous Systems B Lab** Students will demonstrate in a semester project that applications from the area of embedded systems are reliable by using methods, techniques and tools to ensure safety,

	security, availability and reliability. Furthermore, they will be able to apply deep learning algorithms by considering the characteristics of the given system context. They will be able to present the results as part of the practical work in a scientific paper 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.
Content	**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 **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 **Autonomous Systems B Lab** • Based on the methods and techniques learned in Verification and Validation of Cyber-Physical Systems, Deep Learning, and Distributed Systems, a project will be completed in the field of autonomous systems. • Independent planning, analysis, modeling, implementation and testing of a complex application example
Teaching Method	Verification and Validation of Cyber-Physical Systems: Seminar (2 hpw) Deep Learning: Seminar (2 hpw)

	Distributed Systems: 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	Module exam as a presentation (15 - 20 minutes, 3 times 5%) with subsequent paper (5 - 7 pages, 3 times 15%) for each seminar (seminars at all 60%) and examinations in the context of the practical work : the students will independently complete a project. This includes writing a documentation of 2 to 5 pages (20%) and a final presentation of 10 to 15 minutes (20%).
Participation Recommendations	None.
Prerequisite for the award of ECTS credits	Passed final module exam.
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 • M. T. Hagan und H. B. Demuth: Neural Network Design. 2ndEdition. 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 Distributed Systems

	• 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

Module Name	**Embedded Electronic Engineering B**
Module Abbreviation	ELE-B-2-7.07
Module Coordinator	Prof. Dr.-Ing. Ali Hayek

ECTS Credits	15	**Total Workload**	450
HPW	10	**Contact Hours**	150
Language	English	**Self-Study Time**	300

Semester of Study / Frequency of Offer / 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. **Internet of Things (IoT)** The course is an in-depth introduction into IoT. The students will learn the basic technologies and how to design complex applications in the IoT engineering area. They will be able to understand the basic hardware and software concepts of IoT. They can develop and evaluate IoT systems. They know and can apply the IoT connectivity techniques. **Product Lifecycle Management (PLM)** In the course of the "Product Lifecycle Management“ seminar, the students get to know the relevant processes for the 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 development- and production processes. They will be able to identify the main processes of PLM, analyze 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. **Embedded Electronic Engineering B Lab** Students will be able to independently design an application with consideration of VLSI design concepts, IoT and by applying the knowledge of PLM. They will be able to present the results as part of the practical work in a scientific paper 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.
Content	**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 **Internet of Things (IoT)** Enabling technologies for IoT: • Application layers and protocols • Transmission technologies: wireless and wired • Architectures Application areas: • Consumer (smart home & wearables) • Industrial (automation, agriculture, maritime) • Infrastructure (smart cities, energy management) • Organizational (medical & healthcare, transportation, building automation) **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 seminars, a project will be completed in the field of embedded systems / product engineering. • Independent planning, analysis, modeling, implementation and testing of a complex application example
Teaching Method	Advanced Hardware Engineering: Seminar (2 hpw) IoT: 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	Module exam as a presentation (15 - 20 minutes, 3 times 5%) with subsequent paper (5 - 7 pages, 3 times 15%) for each seminar (seminars at all 60%) and examinations in the context of the practical work I: the students will independently complete a project. This includes writing a documentation of 2 to 5 pages (20%) and a final presentation of 10 to 15 minutes (20%).
Participation Recommendations	No formal participation requirements. Students are recommended to have the knowledge and skills typically acquired in the following module and be able to apply them: Hardware engineering 2
Prerequisite for the award of ECTS credits	Passed final module exam.
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 Internet of Things (IoT) • Acharjya, D.P.; Geetha, M.K., eds. (2017). Internet of Things: Novel Advances and Envisioned Applications. Springer. p. 311. ISBN 9783319534725. • Li, S.; Xu, L.D., eds. (2017). Securing the Internet of Things. Syngress. p. 154. ISBN 9780128045053. • 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. • Thomas, Jayant; Traukina, Alena (2018). Industrial Internet Application Development: Simplify IIoT development using the elasticity of Public Cloud and Native Cloud Services. Packt Publishing. p. 25. ISBN 978-1788298599. • Stephenson, W. David (2018). The Future Is Smart: how your company can capitalize on the Internet of Things--and win in a connected economy. HarperCollins Leadership. p. 250. ISBN 9780814439777. 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

Compulsory Modules only for examination regulations from 2017

Module Name	**Industrial Design (only Ex.R. 2017)**
Module Abbreviation	ELE-B-2-1.05
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Credits	5	**Total Workload**	150
HPW	3	**Contact Hours**	45
Language	English	**Self-Study Time**	105

Semester of Study / Frequency of Offer / Duration	1th 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.
Content	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 term paper (7 to 10 pages).
Participation Recommendations	None.

Prerequisite for the award of ECTS credits	Passed final module exam.
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 Name	Interactive Systems Design 1 (only Ex.R. 2017)
Module Abbreviation	ELE-B-2-3.04
Module Coordinator	Prof. Dr. Achim Rettberg

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	90

Semester of Study / Frequency of Offer / 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.
Content	• 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). The actual form of the examination will be announced before the deadline of the exam registration.
Participation Recommendations	None.
Prerequisite for the award of ECTS credits	Passed final module exam.
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 Name	Interactive Systems Design 2 (only Ex.R. 2017)
Module Abbreviation	ELE-B-2-4.03
Module Coordinator	Prof. Dr.-Ing. Ali Hayek

ECTS Credits	5	**Total Workload**	150
HPW	4	**Contact Hours**	60
Language	English	**Self-Study Time**	120

Semester of Study / Frequency of Offer / 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.
Content	• 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	Module exam as an oral exam (20 to 30 minutes).
Participation Recommendations	None.
Prerequisite for the award of ECTS credits	Passed final module exam.
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 Name	Advanced Embedded Systems (only Ex.R. 2017)
Module Abbreviation	ELE-B-2-6.02
Module Coordinator	Prof. Dr. Stefan Henkler

ECTS Credits	10	**Total Workload**	300
HPW	6	**Contact Hours**	90
Language	English	**Self-Study Time**	210

Semester of Study / Frequency of Offer / 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.
Content	**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 (2/6). Industrial Communication Standards: writing a paper (5 to 7 pages, 1/12) and presentation (10 to 15 minutes, 1/12). Advanced Embedded Systems Lab: writing a documentation of 10 - 15 pages (40%) and a final presentation of 10 - 15 minutes (10%).
Participation Recommendations	None.
Prerequisite for the award of ECTS credits	Passed final module exam.
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.