Module Handbook

for the study program

Electrical and Electronics Engineering B.Sc.

Note: Due to the current pandemic situation, corona-related changes in assessment formats may occur. These will be communicated by the lecturer via Moodle

Kleve, Rev. 3 May 2021

Content

Curriculum Electrical Engineering B.Sc

Curriculum EL dual Form		HPW	Type						Examination form		CP	HPW								
			V	SL	S	Ü	Pra	Pro	Attestation	graded		WS1a	WS1b	SS2a	SS2b	WS3	SS4	WS5	SS6	WS7
1st Semester																				
2000	Introductory Mathematics	8	5			3				x	8	8								
2011	Programming	4	2				2		x	x	5	4								
2300	Introduction to Electrical Engineering	3	2		1				x		3	3								
2nd Semester																				
2001	Applied Mathematics	8	5			3				x	7			8						
2003	Physics	4	2			1	1		x	x	5			4						
2012	Advanced Programming	4	2				2		x	x	5			4						
3rd Semester																				
2008	Statics and Strength of Materials	4	2			2				x	5		4							
2013	Business Economics & Project Management	4	3				1		x		5		4							
2301	Electrical Engineering I	4	2			1	1		x	x	5		4							
4th Semester																				
2302	Electrical Engineering II	4	2			1	1		x	x	5				4					
2303	Digital Electronics	4	2			1	1		x	x	5				4					
2304	Analog Electronics	4	2			1	1		x	x	5				4					
5th Semester																				
2014	Cross-Cultural Management and Creativity	4	2			2			x		5					4				
2306	Microcontrollers	4	2				2		x	x	5					4				
2307	Fields and Waves	4	2			2				x	5					4				
2308	Signal Transmission	4	2			1	1			x	5					4				
2309	Object oriented Programming	4	2				2			x	5					4				
2901	Drives and Power Electronics	4	2			2				x	5					4				
6th Semester																				
2323	Materials and Manufacturing of Electronics	4	3			1				x	5						4			
2311	Embedded Systems	4	2				2			x	5						4			
2310	Signal Processing & Measurement Technology	4	1			1	2			x	5						4			
2902	System Theory and Controls	4	2			1	1			x	5						4			
	Focus Field (see catalogue individual subjects: Focus Fields)																			
	Focus Field Subject 1	4									5						4			
	Focus Field Subject 2	4									5						4			
7th Semester																				
2015	Group Project	1						1	x		5							1		
2312	Microelectronic Control Systems	4	2			1	1		x		5							4		
2325	**Communication Networks**	4	2			2				x	5							4		
2314	Practical Electronics	4	2			1	1			x	5							4		
	Focus Field (see catalogue individual subjects: Focus Fields)																			
	Focus Field Subject 3	4									5							4		
	Focus Field Subject 4	4									5							4		
8th Semester																				
2016	Internship / Semester abroad								x		30									
9th Semester																				
2017	Bachelor Thesis									x	12									
2018	Colloquium									x	3									
2510	Technology and Innovation Management	4	2				2			x	5									4
2512	Entrepreneurship	2						2	x		2									2
	Elective (see catalogue individual subjects: Electives)	3									5									3
Overview		133	V	SL	S	Ü	Pra	Pro	Attestation	graded	210	15	12	16	12	24	24	21		9
		HPW	Type						Examination form		CP	WS1a	WS1b	SS2a	SS2b	WS3	SS4	WS5	SS6	WS7
												HPW								

Catalogue Individual Subjects EL		HPW	Type						Examination form		CP	HPW								
			V	SL	S	Ü	Pra	Pro	Attestation	graded		WS1a	WS1b	SS2a	SS2b	WS3	SS4	WS5	SS6	WS7
Focus Fields *//***/******																				
	Focus Field Electronics	12	8			4	0				20						6	6		
2315	Low Power Design	3	2			1				x	5						3			
2316	Design of env. friendly Circuits and Recycling of Electr.	3	2			1				x	5						3			
2317	Optoelectronics	3	2			1				x	5							3		
2318	Nanoelectronics	3	2			1				x	5							3		
	Focus Field Communication	13	7			3	3				20						6	7		
2319	Mobile Information Devices	3	2				1			x	5						3			
2320	Audio & Speech Processing	3	2				1			x	5						3			
2321	Biomedical Electronics	4	2			2				x	5							4		
2322	Networks in Industrial Automation	3	1			1	1			x	5							3		
	Focus Field Controls	15	8			4	3				20						7	8		
2002	Numerical Mathematics	4	2			2				x	5						4			
2324	**Brain Computer Interfaces**	3	2				1			x	5						3			
2903	Controls	4	2			1	1			x	5							4		
2907	Sensors & Actuator Networks	4	2			1	1			x	5							4		
	Alternative Modules +	8									10									
2020	Foreign Language / free elective	4									5						4			
2020	Foreign Language / free elective	4									5							4		
Electives																				
2019	Scientific Methods (Block or online)	4	2			2			x		5									4
2020	Foreign Language								x		5									
2021	Module from any other Bachelor study course HSRW								x	x	5									

Explanations / Conditions

* Die Fakultät behält sich das Recht vor, sowohl eine Mindestteilnehmerzahl für das Zustandekommen eines Faches im Fokusfeld / Wahlbereich als auch eine Maximalteilnehmerzahl festzulegen. Die Möglichkeit des Erreichens der vorgeschriebenen Kreditpunktanzahl aus dem Vertiefungsfeld bleibt unberührt./ * The faculty reserves the right to determine a minimum and a maximum number of participants for offering a subject in the focus fields / electives. The possibility to obtain the required number of credit points remains unaffected.

** Aus dem Wahlbereich können mit dem Einverständnis des Prüfungsausschuses der Fakultät Technologie und Bionik auch Fächer mit einem Gesamtumfang von 5 Kreditpunkten aus dem gesamten Bachelor-Studienangebot der Hochschule Rhein Waal gewählt werden / As elective a maximum of 5 CP can be chosen with the consent of the examination committee of the faculty Technology and Bionics from any Bachelor study programme at the Rhine-Waal University of Applied Science.

*** Die Fakultät Technologie und Bionik behält sich das Recht vor, das Fächerangebot im Wahlbereich zu ändern / The faculty Technology and Bionics reserves the right to change the catalogue of electives.

**** Aufgrund von stundenplantechnischen Randbedingungen ist nicht auszuschließen, dass Fächer verschiedener Fokusfelder sowie Fächer des Wahlbereichs zeitgleich angeboten werden / Due to time tabling constraints subjects from different focus fields and electives may be offered concurrently.

\+ Bei Wahl eines dieser Alternativmodule kann kein komplettes Fokusfeld mehr belegt werden / Selecting one of these modules leads to loosing the focus field namend on your degree.

Abbreviations

- HPW Semesterwochenstunden / hours per week
- CP Kreditpunkte / credit points
- V Vorlesung / lecture
- SL Seminaristische Vorlesung / seminar lecture
- S Seminar / seminar
- Ü Übung / exercise
- Pra Praktikum / practical work
- Pro Projekt / project
- WSx Wintersemester / winter semester
- SSx Sommersemester / summer semester

2000 Introductory Mathematics

Module name/Module code:	Introductory Mathematics 2000
Degree:	Biomaterials Science: BMS 1 2000 Electrical and Electronics Engineering: EL 1 2000 Industrial Engineering: IE 1 2000 Mechanical Engineering: ME 1 2000 Mechatronic Systems Engineering: MSE 1 2000
Module coordinator:	Prof. Dr. A. Kehrein
Lecturer:	Dr. T. Camps Prof. Dr. A. Kehrein
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 5 HPW Exercise: 3 HPW
Workload:	120 h attendance 90 h preparation and review 30 h exam preparation
Credits:	8
Recommended prerequisites:	High school: Algebra, Exponential function and Logarithm, Trigonometry
Module objectives:	Students are able to gain knowledge in various ways and learn to organize their work. Students understand basic mathematical concepts and know how to apply standard mathematical methods. They are able to visualize mathematical objects and to interpret mathematical symbols and formulas. They have learned to think, to work and to express themselves with precision. Also they have acquired a feeling for handling numbers. They possess the skills to solve problems on their own and to verify the solutions. They are able to apply numerical as well as graphical solution methods to various tasks. The students will possess general problem solving skills beyond the simple application of standard procedures.
Content:	• Numbers: irrational numbers and the difficulties associated with their representation on a pocket calculator or computer, complex numbers and the Fundamental Theorem of Algebra • Systems of linear equations: Gaussian elimination • Vector algebra and analytic geometry: linear combinations, scalar and vector products, lines and planes • Limits: concept and computation, continuity, bisection method • Differential calculus: definition of derivative, rules of derivation, tangent, Newton's method, monotonicity and concavity • Integral calculus: inversion of differentiation – indefinite integral, area calculation – definite integral, Fundamental Theorem of Calculus

	• Integral calculus: substitution rule, integration by parts, partial fraction decomposition, improper integrals
Assessment:	Written digital examination
Forms of media:	Moodle, Webex
Literature:	1. James Stewart (2011). *Calculus*. Metric International Version. 7th edition. Brooks/Cole Further Reading: 2. James Stewart, Lothar Redlin, Saleem Watson (2012). *Algebra and Trigonometry.* 3rd international edition. Brooks/Cole [to catch up on basic mathematics]

2001 Applied Mathematics

Module name/Module code:	Applied Mathematics 2001
Degree:	Biomaterials Science: BMS 2 2001 Electrical and Electronics Engineering: EL 2 2001 Industrial Engineering: IE 2 2001 Mechanical Engineering: ME 2 2001 Mechatronic Systems Engineering: MSE 2 2001
Module coordinator:	Prof. Dr. A. Kehrein
Lecturer:	Dr. T. Camps Prof. Dr. A. Kehrein
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 5 HPW Exercise: 3 HPW
Workload:	120 h attendance 75 h preparation and review 30 h exam preparation
Credits:	7
Recommended prerequisites:	2000 Introductory Mathematics
Module objectives:	Students are able to use advanced mathematical concepts and methods. In particular, they are able to work with multivariate functions and master modelling with differential equations. Students learn to model situatons that involve uncertainty and to calculate with discrete as well as continuous random variables. They learn how to draw conclusions about a population when only sample data is available. In particular, measurements are interpreted as samples. The fundamentals of probability theory that are necessary for this purpose are demonstrated empirically by data from student experiments. Students practice their general social skills by working in small teams on their homework. They specifically train to communicate in precise mathematical terms. By means of their homework, students improve their problem solving skills.
Content:	• Linear algebra: matrices, determinants, inverse matrix, eigenvalue problems • Series: approximations using partial sums, convergence and divergence tests, power series, Taylor series • Differential calculus of several variables: partial derivatives, gradient, extrema • Ordinary differential equations: direction field, separating variables, linear differential equations of first and second order

	• Probability: Modelling random experiments, meaning of probability, Law of Large Numbers, conditional probability, probability trees, Bayes' theorem • Random variables: discrete and continuous, probability mass functions and probability density functions, normal distribution • Sample theory: sample average, central limit theorem, variance of sample average
Assessment:	Written examination
Forms of media:	Whiteboard, Projector
Literature:	1. James Stewart (2016): *Calculus*. Metric International Version. 8th edition. Brooks/Cole 2. John Devore (2008) *Probability and Statistics for Engineering and the Sciences*. 7th int. student edition. Brooks/Cole 3. DeVeaux, Velleman, Bock (2004) *Stats: Data and Models*. Pearson 4. Freedman, Pisani, Purves (2007) *Statistics*. 4th edition. Norton Recommended Video Lectures: 5. Mattuck, Arthur, Haynes Miller, Jeremy Orloff, and John Lewis. *18.03SC Differential Equations,Fall 2011*. (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu (Accessed 08 May, 2013). License: Creative Commons BY-NC-SA 6. Strang, Gilbert. *18.06SC Linear Algebra,Fall 2011*. (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu (Accessed 08 May, 2013). License: Creative Commons BY-NC-SA

2002 Numerical Mathematics

Module name/ Module code:	Numerical Mathematics 2002
Degree:	Industrial Engineering: IE 4 2002 Mechanical Engineering: ME 4 2002 Mechatronic Systems Engineering: MSE 4 2002 Biomaterials Science BMS 4 2002 Electrical and Electronics Engineering EL 4 2002
Module coordinator:	Prof. Dr. A. Kehrein
Lecturer:	Prof. Dr. A. Kehrein Dr. T. Camps
Language:	English
Place in curriculum:	Core: IE, ME, MSE Focus Field subject: BMS, EL
Timetabled hours:	Lectures: 3 HPW Exercise: 1 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	2000 Introductory Mathematics 2001 Applied Mathematics 2011 Programming
Module objectives:	The students learn that use of a computer introduces new mathematical difficulties: not all numbers are representable; there are round off errors and propagation errors. Mathematically equivalent formulas may produce different results on a computer. The students learn how to do computations effectively within the machine limitations. The students learn some standard methods of numerical mathematics but, more importantly, that numerical methods must be developed to fit the problem at hand. The students become active learners and look for applications of the new methods on their own. They become independent in checking the correctness of their results.
Content:	• Presentation of numbers in a computer: INT and FLOAT; round off errors • Loss of significant digits, error propagation • Interpolation: Lagrange polynomials and splines • Numerical differentiation: use of Taylor approximations, order of a numerical method, truncation error • Numerical integration: midpoint rule, trapezoid rule, Romberg scheme • Fixed-point iteration • Iterative solution of non-linear systems, in particular Newton's Method

	• Numerical solution of differential equations: forward and backward Euler, Runge-Kutta, difference equations, stability, implicit vs. explicit schemes
Assessment:	Written examination
Forms of media:	Whiteboard, projector
Literature:	1. Forman S. Acton (2005) *Real Computing Made Real – Preventing Errors in Scientific and Engineering Calculations*. Mineola. Dover Publications. 00/TKX 19´ 2. Cleve Moler (2004) *Numerical Computation with Matlab*, Society for Industrial and Applied Mathematics (pdf available from https://de.mmathworks.com/moler/chapters.html) 3. Gilbert Strang (2007) *Computational Science and Engineering*. Wellesley. Wellesley-Cambridge Press. 00/TKX 3 4. Richard Burden and Douglas Faires (2011) *Numerical Analysis*. 9th international edition. Brooks/Cole. 00/TKX 17 5. Parviz Moin (2010) *Fundamentals of Engineering Numerical Analysis*. 2nd edition. Cambridge. Cambridge University Press. 00/WAT 1 6. William Press, Saul Teukolsky, William Vetterling, Brian Flannery (2007) *Numerical Recipes – The Art of Scientific Computing*. 3rd edition. Cambridge. Cambridge University Press. (online materials available from http://numerical.recipes) 00/TKX 5

2003 Physics

Module name/ Module code:	Physics 2003
Degree:	Biomaterial Science: BMS 1 2003 Electrical and Electronics Engineering: EL 2 2003 Industrial Engineering: IE 2 2003 Mechanical Engineering: ME 2 2003
Module coordinator:	Prof. Dr. G. Bastian
Lecturers:	Prof. Dr. G. Bastian Prof. Dr. A. Struck H. Derksen
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical training: 1 HPW
Workload:	60 h attendance 15 h exercise preparation and review 45 h lab reports 30 h exam preparation
Credits:	5
Recommended prerequisites:	none
Module objectives:	Physics: Students will be able to explain and understand technological and scientific phenomena using the knowledge learnt. Processes, effects and phenomena can be approached quantitatively and the necessary physical equations for this can be adapted and applied. The ability to set up, execute, analyse and assess physical experiments. Students will be able to present their own results in laboratory reports using appropriate technical terms in English and in digital form. Physics Laboratory: The students are able to work safely in the laboratory using basic laboratory techniques and write lab reports.
Content:	Physics: • Physical units and measurement errors • Mechanics and kinematics • Oscillations and waves Physics Laboratory: • Covers content of the corresponding lectures
Assessment:	Physics: Written examination on campus Physics Laboratory: Attestation on campus
Forms of media:	Webex, Moodle, laboratory equipment on campus
Literature:	Tipler: Physics for Scientists and Engineers

2008 Statics and Strength of Materials

Module name/Module code:	Statics and Strength of Materials 2008
Degree:	Biomaterials Science: BMS 3 2008 Electrical and Electronics Engineering: EL 1 2008 Industrial Engineering: IE 1 2008 Mechanical Engineering: ME 1 2008 Mechatronic Systems Engineering: MSE 1 2008
Module coordinator:	Prof. Dr.-Ing. H. Schütte
Lecturer:	Prof. Dr.-Ing. H. Schütte
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 2 HPW Exercise: 2 HPW
Workload:	90 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	School knowledge of Physics and Mathematics
Module objectives:	Students are able to sum and decompose concurrent forces in two dimensions. They are able to calculate moments and combine them in the plane. Building on these skills they can analyse the forces and torques that act on a rigid body in equilibrium conditions. Students are able to determine the centroid of an arbitrary line or area. Based on this knowledge, students are able to analyse planar and multi-piece structures. Furthermore, they are able to determine the forces in the members of a simple truss using the method of joints. They are able to determine the distribution of normal, transversal and bending moments for statically determined beams. Students are able to understand the concept of normal and shear stresses. They know the stress distributions in rods, shafts and beams and are able to calculate the maximum stresses due to the respective loadings. Students apply the knowledge gained in the lectures to regular exercises for solving selected tasks, thereby reinforcing their learning.
Content:	1. Fundamentals 1.1 Definition of force as vector 1.2 Newtonian laws 1.3 Rigid body 1.4 Cutting principle 2. Forces with a common point of origin 2.1 Composition of forces in a plane 2.2 Dismantling of forces in a plane 2.3 Equilibria in a plane 3. Force systems and equilibrium of the rigid body

	3.1 Forces in a plane 3.2 Torque vector 4. Median point 4.1 Median point and centre of mass of a body 4.2 Centroid of an area 4.3 Centroid of a line 5. Bearing reactions 5.1 Plain structures 5.2 Simple multi-piece structures 6. Beams 6.1 Support reactions for beams 6.2 Internal forces in beams 7. Stresses 7.1 Normal and Shear Stresses and their effects 7.2 Stress distributions due to axial loading, torque and bending 7.3 Maximum stresses due to torque and bending 7.4 Failure models
Assessment:	Written digital examination Accompanying online course
Forms of media:	Webex/Moodle
Literature:	1. Ferdinand Beer, Jr. Johnston, John DeWolf, David Mazurek: Statics and Mechanics of Materials, 2nd edition, ISBN 9780073398167 2. Lecture Notes

2011 Programming

Module name/Module code:	Programming 2011
Degree:	Biomaterials Science: BMS 1 2011 Electrical and Electronics Engineering: EL 1 2011 Industrial Engineering: IE 1 2011 Mechanical Engineering: ME 1 2011 Mechatronic Systems Engineering: MSE 1 2011
Module coordinator:	Prof. Dr. M. Krauledat
Lecturer:	Prof. Dr. M. Krauledat Prof. Dr. R. Hartanto Dr. T. Camps
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	
Module objectives:	After successful completion of this module, students are able to • recognize limitations and complexity of computer based operations • Use algorithmic concepts such as recursion • transfer technical problems to program code • implement simple algorithms • analyse results of mathematical calculations using appropriate tools such as graphical plots and numeric computations
Content:	Algorithmic Concepts • Input and Output • Recursion and iteration Program structures using a high-level programming language • Syntax and Semantics • Data Visualization: plotting in MATLAB • MATLAB program structures (m-files): scripts and functions • Basic programming structures: conditional statements, loops • Symbolic determination of derivatives and integrals • Built-in numerical methods • Basic tools for graphical modelling and simulation (e.g. Simulink)
Assessment:	Lecture: Written examination on campus Exercise: Attestation by continuous assessment

Forms of media:	Webex/Moodle
Literature:	Stormy Attaway (2012). *MATLAB – A Practical Introduction to Programming and Problem Solving*. 2nd edition. Butterworth-Heinemann.

2012 Advanced Programming

Module name/Module Code:	Advanced Programming 2012
Degree:	Electrical and Electronics Engineering: EL 2 2012 Mechatronic Systems Engineering: MSE 2 2012
Module coordinator:	Prof. Dr. M. Krauledat
Lecturer:	Prof. Dr. M. Krauledat, Prof. Dr. R. Hartanto,
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 90 h preparation and review
Credits:	5
Recommended prerequisites:	2011 Programming
Module objectives:	After successfully finishing the module, students are able to • develop short programs in C • analyze program code • Use advanced data structures to implement algorithms
Content:	Programming • Introduction to Programming in C • Tools for program development • Data types, operators and terms • Input and output • Flow control • Program structures • Functions • References and pointers • Data structures • Searching and Sorting • Strings • Practical programming exercises with C
Assessment:	Lecture: Written examination Exercise: Attestation
Forms of media:	Whiteboard, PowerPoint, Projector, PC Pools
Literature:	1. King, K.N. (2008) *C Programming – A Modern Approach*. 2nd edition . Norton 2. Griffiths, David and Griffiths, Dawn (2012) *Head First C.* O'Reilly Further Readings:

	3. Kernighan, Brian W. and Ritchie, Dennis M.: The C Programming Language, 2nd edition, Prentice Hall International, ISBN 978-0131103627, 1988 4. M. Sipser, „Introduction to the theory of computation“ (3rd ed.), Cengage Learning 2013 5. J. G. Brookshear, „Computer Science – an overview“ (11th ed.), Pearson 2012 Recommended Video Lectures: 6. Malan, David J.: *CS 50 Introduction to Computer Science I, 2011- 2013.* (Harvard University: OpenCourseWare) http://cs50.tv/2011/fall/ (Accessed 02 Mar, 2014). License: Creative Commons BY-NC-SA

2013 Business Economics & Project Management

Module name/Module code:	Business Economics & Project Management 2013
Degree:	Biomaterials Science: BMS 3 2013 Electrical and Electronics Engineering: EL 1 2013 Mechanical Engineering: ME 1 2013 Mechatronic Systems Engineering: MSE 1 2013
Module coordinator:	Prof. Dr. D. Berndsen
Lecturer:	Business Economics: Prof. Dr. D. Berndsen Project Management: Prof. Dr.-Ing. D. Untiedt
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 3 HPW Practical training: 1 HPW
Workload:	60 h attendance 45 h preparation and review 45 h exam preparation
Credits:	5
Recommended prerequisites:	None
Module objectives:	Students acquire a good initial overview and insight into the environment and inner workings of a business organization, focused on manufacturing firms. They understand the basics of different business models and can recognize the strategic rationales for various types of observable business behaviour. More specifically, they know the relevant market and legal environment, stakeholders and typical key objectives of several types of business, with most emphasis on the manufacturing firm. They understand how the performance of such an enterprise can be measured and reported. They know the basic structure and contents of Balance Sheets, Income and Cash Flow Statements. They can make basic evaluations of a business' performance based on information gathered from these statements. Students understand the financing needs of different types of business, and know the most common ways to address them. They can identify the key functions of a business and understand their regular interactions based on the value chain, with particular emphasis on value creation in a manufacturing firm. They also understand the role of project-driven activity in such an enterprise, have a basic knowledge on how different types of project are organized and managed, and which outcomes can be expected. They understand basic project-related information and know the fundamentals of select project management techniques.

Content:	<u>Business Economics</u> • Definition and roles of a business • Market structures, market typology and market influences • Business models (with special emphasis on manufacturing firms) • Business objectives and strategy • Legal environment and legal setups • Financial statements - balance sheet, income statement, statement of cash flow • Additional reporting, codes of conduct and compliance • Overview business functions • Marketing and Sales – brief introduction • Purchasing / Procurement – brief introduction • Logistics – brief introduction • Production / Operations – brief introduction • R&D – brief introduction, the role of data-driven innovation • Human Resources – brief introduction • Finance – key concepts, basics of corporate performance management <u>Project Management</u> • Fundamentals of organizational design • Business decision making and the role of management and leadership • Structure vs. process vs. project • Project stakeholders and project roles • Principles of programme, portfolio, and project management • Project life cycle planning and control • Project governance and basics of risk management • Documenting and managing results • Project management software
Assessment:	Business Economics: digital attestation Project Management: continuous assessment and digital attestation
Forms of media:	Webex/Moodle
Literature:	<u>Business Economics</u> 1. Nickels, William G. / McHugh, James / McHugh, Susan (2015): Understanding Business. 11th edition, ISBN 978-9814670371, McGraw-Hill 2. Hughes, Robert / Kapoor, Jack R. / Pride, William M. (2014): Business. EMEA edition. ISBN 978-1473704763, Cengage Learning 3. Brealey, Richard A. / Myers, Stewart C. / Allen, Franklin (2016): Principles of Corporate Finance. 12th edition, ISBN 978-1259253331, McGraw-Hill

	4. Osterwalder, Alexander et al. (2014): Value Proposition Design: How to Create Products and Services Customers Want (Strategyzer). ISBN 978-1118968055, Wiley Ries, Eric (2011): The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. ISBN 978-0670921607, Portfolio Penguin <u>Project Management</u> 5. Project Management Institute (Ed.) (2013): A Guide to the Project Management Body of Knowledge (PMBOK Guide) (Pmbok#174; Guide), 5th edition, ISBN 978-1935589679, PMI 6. Berkun, Scott (2008): Making Things Happen. Mastering Project Management. ISBN 978-0596517717, O'Reilly Anderson, David J. (2010): Kanban: Successful Evolutionary Change for Your Technology Business. ISBN 978-0984521401, Blue Hole Press 7. Additional literature referenced in class (to be updated shortly before new study programme starts)
Other self-study materials	• Complete lecture slides provided to students using interactive e-learning system (HSRW Moodle) • Further readings in public domain (e.g. open courseware or wikipedia articles on selected topics) • Sample exams • Catalogue of possible questions for exam preparation

2014 Cross-Cultural Management and Creativity

Module name/Module code:	Cross-Cultural Management and Creativity 2014
Degree:	Biomaterials Science: BMS 1 2014 Electrical and Electronics Engineering: EL 3 2014 Industrial Engineering: IE 2 2014 Mechanical Engineering: ME 2 2014 Mechatronic Systems Engineering: MSE 5 2014
Module coordinator:	A. Viermann
Lecturer:	A. Viermann D. Ziegler (external lecturer)
Language:	English
Place in curriculum:	Core
Timetabled hours:	Cross-Cultural Management: Lecture & Exercise 3 HPW Creativity: Lecture & Exercise 1 HPW
Workload:	60 h attendance 90 h preparation and review and group assignment
Credits:	5
Recommended pre-requisites:	none
Module objectives:	The aim of this module is to support students to build up cross-cultural competences (cognitive, affective and communicative) and to gain first basic knowledge and abilities to deal with creative processes in individual, team or organisational settings. For this, the students will • develop a deepened understanding of the dangers and potential arising from humans dealing with differences. • reflect on the impact of different dimensions of diversity in business context. • get an understanding of the term and nature of 'CULTURE' • self-reflect and look into effects of dealing with change situations (e.g. culture shock) and reflect on coping strategies. • study different cultural models and get to know different dimensions of culture (e.g. Hofstede). On this basis, reflect and develop an awareness of the student's individual cultural background in contrast to other cultures in respect to values and behaviour. This supports students to become more self-reflective and mindful as well as develop learning strategies for dealing with negative vibes from cultural differences. • experience working within multi-cultural teams and combine theoretical and empirical work while working on topic related projects. • develop awareness of and reflect on the importance of creativity. • be equipped with a repertoire of methods and strategies that support creative processes and know-how to build a supportive work environment and innovative climate in organizations to make best use of creative potentials.

	• through group work, improve their intercultural collaboration and communication skills as well as presentation abilities.
Content:	Cross-Cultural Management: • Dealing with differences • Diversity in business environment • Globalisation of markets and economies and the need for cross-cultural competence • Definitions of culture and their key aspects • Culture shock • Cultural models and dimensions of culture • Reflect on the student’s individual cultural background in relation to other cultures and on the impact of cultural differences in business environment Creativity: • Definition of creativity • Impact of creativity on business innovation and the creation of sustainable competitive advantages • Key components of individual creativity and team creativity • Getting to know different classical creativity techniques and new approaches to creativity • Frame conditions for creativity and innovation in organizations
Assessment:	Attestation: Group assignments: preparation, submission and oral presentation (40%) and a written assignment (term paper) (60%)
Forms of media:	Webex/Moodle
Literature:	1. Hofstede, Geert: Cultures and Organizations, (2010, Mcgraw-Hill) 2. Trompenaars, Fons: Riding the Waves of Culture, (2012, Brealey Publishing) 3. Lewis, Richard: When cultures collide – Leading across cultures (2006, Brealey Publishing) 4. De Bono, Edward: Serious Creativity, (2015, Vermilion // Trade Paperback) 5. Keeley, Larry Ten Types Of Innovation, (2013, Wiley) 6. Michalko, Michael: Thinkertoys, (2006,Ten Speed Press) 7. Wolff, Jurgen: CREATIVITY NOW, (2012, Pearson International) 8. Van Aerssen, B. et al: The Innovator's Dictionary, (2018, Vahlen) V9. on Oech, Roger: A Kick In The Seat Of The Pants, (1986, Warner Books) 10. Supplemental readings, e.g. additional literature, exercises, cases and other learning materials will be provided during class.

2015 Group Project

Module name/Module code:	Group Project 2015
Degree:	Biomaterials Science: BMS 5 2015 Electrical Engineering: EL 5 2015 Industrial Engineering: IE 5 2015 Mechanical Engineering: ME 5 2015 Mechatronic Systems Engineering: MSE 5 2015
Module coordinator:	Heads of the degree programme
Lecturer:	Prof. Dr.-Ing. D. Untiedt (IE) Prof. Dr. R. Hartanto (EL) Prof. Dr.-Ing. H. Schütte (MSE) K. Schacky (ME,)
Language:	English
Place in curriculum:	Core
Timetabled hours:	Project: 1 HPW
Workload:	15 h attendance 135 h project workload
Credits:	5
Recommended prerequisites:	
Module objectives:	Students work on solutions for a given task in teams (in exceptional cases individually). For this, students create a functional specifications document and calculate project costs and necessary capacities. They present their self-designed concepts to their clients and are able to defend these concepts. Students react constructively to suggestions and criticism and further develop their approaches into a marketable product. They determine implementation and product costs and are able to estimate market potentials. Students contact suppliers and decide on purchase of material and components. Apart from content-related processing, students also master documenting and presenting the results and thereby interact with potential customers.
Content:	Contents are course-specific
Assessment:	Attestation: Continuous Assessment
Forms of media:	Webex/Moodle
Literature:	1. C. M. Anson and R. A. Schwegler: The Longman Handbook for Writers and Readers, fourth edition, Pearson Education Inc., 2005 2. G. Pahl, W. Beitz, J. Feldhusen, K.H. Grote: Engineering Design – A Systematic Approach, 3rd ed. 2007 (4. November 2014), Springer, 2014 3. Selected state-of-the-art papers

2016 Internship / Semester Abroad

Module name/Module code:	Internship / Semester Abroad 2016
Degree:	Biomaterials Science: BMS 6 2016 Electrical and Electronics Engineering: EL 6 2016 Industrial Engineering: IE 6 2016 Mechanical Engineering: ME 6 2016 Mechatronic Systems Engineering: MSE 6 2016
Module coordinator:	Heads of the degree programme
Lecturer:	Professors
Language:	English
Place in curriculum:	Core
Timetabled hours:	None
Workload:	900 h
Credits:	30
Prerequisites:	90 CP from the curriculum
Module objectives:	**Internship Semester:** Student's work in one or more functional units of an enterprise. They will apply their gained knowledge and methods in technical, analytical, and social matters. The students will have to use their theoretical gained knowledge in their respective practical discipline and reflect it afterwards. Students have to use the following key skills: • Interdisciplinary project work • Intercultural skills • Transfer theoretical knowledge into the practical knowledge • Organization and self-management skills • Set priorities and organize work according to priorities • Team oriented work and communication skills • English as international language • Ability to handle changes during task • Work under pressure of time The internship can be completed abroad. **Semester abroad:** Students can decide to substitute the internship semester with a study abroad semester. Selecting a study abroad semester offers the student to being immersed into a different educational system and helps therefore understanding other tertiary systems. Study abroad is further defined as a semester at a university in a country other than their nationality or country of origin.

	The study abroad semester tailors a strengthening of the following key skills: • Deepen and broaden their knowledge of certain subjects (e.g. additional courses) • Gain knowledge of other political, economic, and cultural systems • Widen the cultural background • Increase language capabilities • Widen their social competencies • Interdisciplinary project work • Intercultural skills • Organization and self-management skills • Interdisciplinary team oriented work and communication skills • English as international language • Planning and set-up skills Students will increase their intercultural competencies and get an insight into a different culture as well as organization including many administrative tasks.
Content:	Internship Semester: The contents of the internship are based on the business activities and the business environment of the company. They are closely coordinated between the company and the university, so that a consistent professional tie is guaranteed to the study. Semester Abroad: The contents of the Semester abroad are based on the university programs selected by the student. They are closely coordinated between the sending university and the receiving university, so that a consistent professional tie is guaranteed to the study.
Assessment:	Attestation

2017 Bachelor Thesis

Module name/Module code:	Bachelor Thesis 2017
Degree:	Biomaterials Science: BMS 7 2017 Electrical and Electronics Engineering: EL 7 2017 Industrial Engineering: IE 7 2017 Mechanical Engineering: ME 7 2017 Mechatronic Systems Engineering: MSE 7 2017
Module coordinator:	Heads of the degree programme
Lecturer:	Supervisor of the bachelor thesis
Language:	English
Place in curriculum:	Core
Timetabled hours:	None
Workload:	360 h
Credits:	12
Prerequisites:	175 CP in the respective courses
Module objectives:	The students • demonstrate their capability to work independently on a subject in alignment with their course of studies, meeting all topical and scientific requirements in a limited period of time • are able to organize their workflow in order to meet the demands of the problems formulated in their theses, as well as to monitor progress and make necessary amendments • are able to document their approach and their results to meet the requirements of a scientific publication
Content:	Thesis content depends on the chosen topic and is agreed upon with the supervisor. Documentation is granted by an adequately sized description of the topic/problem, the chosen approach, used methods and results.
Assessment:	Written and graded thesis in the range of 15000 to 20000 words (50–70 DIN A4 pages)

2018 Colloquium

Module name/Module code:	Colloquium 2018
Degree:	Biomaterials Science: BMS 7 2018 Electrical and Electronics Engineering: EL 7 2018 Industrial Engineering: IE 7 2018 Mechanical Engineering: ME 7 2018 Mechatronic Systems Engineering: MSE 7 2018
Module coordinator:	Heads of the degree programme
Lecturer:	Supervisor of the Bachelor Thesis
Language:	English
Place in curriculum:	Core
Timetabled hours:	None
Workload:	90 h
Credits:	3
Prerequisites:	207 CP in the respective courses
Module objectives:	The students • are able to defend the results of the Bachelor Thesis • place their work in a suitable context and present their results in a proper form for the audience. They are able to explain their approach and to critically analyse their own results. • are able to analyze questions concerning their thesis and results and answer them suitably.
Content:	Content is aligned with the content of the Bachelor Thesis, with an operative focus on discussion of their results, methods and alternatives.
Assessment:	Oral examination, graded
Forms of media:	Whiteboard, PowerPoint, Projector
Literature:	1. M. Powell: Presenting in English – how to give successful presentations, Heinle Cengage Learning, 2011 2. S. Krantman: The Resume Writer's Workbook, fourth edition, South-Western Cengage Learning, 2013

2019 Scientific Methods

Module name/Module code:	Scientific Methods 2019
Degree	Biomaterial Science: BMS 7 2019 Electrical and Electronics Engineering: EL 7 2019 Industrial Engineering: IE 7 2019 Mechanical Engineering: ME 7 2019
Module Coordinator:	Heads of the degree programme
Lecturer:	K. Kaminski (External Lecturer)
Language:	English
Part of Curriculum	Elective
Timetable hours	Lecture: 2 HPW Exercise: 2 HPW
Workload	150 h
Credits:	5
Recommended prerequisites:	
Module objectives:	The course offers an introduction to the ethics and logic of science as well as to some methods helpful for the investigation of technical questions. Beside methodological aspects the students understand their ethic responsibility as a scientist and reflect their work based on social impacts and scientific rules. The students know scientific misconduct like fabrication, falsification, copyright violation, wrong citation, plagiarism, violation of ethical standards etc. The students are able to get a full overview over their topic and use literature research for this. They repeat the basic principles of scientific procedure and are able to practically implement their knowledge on a scientific question. They are aware of the differences between theory and empiricism as well as between deductive and inductive reasoning. The students reflect their work accordingly. In case experimental validations of phenomena are required they are able to structure their test program using design of experiments. The students evaluate the limits for testing, they define and rate the required simplifications. Research results are analysed statistically and reflected critically in order to evaluate the quality of the results. Finally, the students prepare the results specific to a target groups.
Content:	Methodological principles encompass the entire process of the scientific questioning • Science ethics - what is allowed - what shall remain unexplored • Ethical standards in science • Social impacts of science • Analysis of the scientific question • Literature research • Definition state of the art • Introduction to the logic of science

	• Inductive vs. deductive reasoning • Formulation of hypotheses • Verification and falsification of hypotheses • Degree of testability • Simplification and probability • Design of experiments • Numerical and graphical data analysis • Descriptive and analytical statistics • Presentation of data / results • Publication of the results in different forms (report, paper, poster, web pages etc.)
Assessment:	Attestation: Continuous Assessment
Forms of media:	Webex/Moodle
Literature:	1. Karl R. Popper: The Logic of Scientific Discovery, ISBN 978-0415278447, reprint 2004, Taylor & Francis 2. Douglas Montgomery, George Runger: Applied Statistics and Probability for Engineers. SI Version. 5th edition, Wiley, 2011 Further Readings: 3. Geoffrey Vining, Scott Kowalski: Statistical Methods for Engineers. 3rd edition. Brooks/Cole, 2011 4. Douglas Montgomery: Introduction to Statistical Quality Control. 5th edition. Wiley, 2005

2020 Foreign language

Module name/Module code:	Foreign language 2020
Degree:	Biomaterials Science: BMS 7 2020 Electrical and Electronics Engineering: EL 7 2020 Industrial Engineering: IE 7 2020 Mechanical Engineering: ME 7 2020 Mechatronic Systems Engineering: MSE 7 2020
Module coordinator:	Heads of the degree programme
Lecturer:	acc. selected module of the language center
Language:	English
Place in curriculum:	Elective: The choice of the students has to be confirmed by the study program coordinators to avoid clashes with core subjects and to ensure the fitting to the study program.
Timetabled hours:	Recommended: 4 HPW
Workload:	acc. module description
Credits:	5
Recommended prerequisites:	none
Module objectives	At the beginning of the course the students define a language level to be achieved based on the existing language skills in the chosen language. This happens together with the responsible teacher. The expected improvement of the language skills has to be defined in a learning agreement. For international students this language should be German, for German students any other language offered by the language center of the university can be selected. After completion of the module the students should be able to communicate better in an additional foreign language. They are able to prepare documents required for applications in Germany or abroad.
Content:	acc. module description of the selected module of the language center
Assessment:	Attestation
Forms of media:	acc. module description of the selected module of the language center
Literature:	acc. module description of the selected module of the language center

2021 Module from any other Bachelor study course HSRW

Module name/Module code:	Module from any other Bachelor study course HSRW 2021
Degree:	Biomaterials Science: BMS 7 2021 Electrical and Electronics Engineering: EL 7 2021 Industrial Engineering: IE 7 2021 Mechanical Engineering: ME 7 2021 Mechatronic Systems Engineering: MSE 7 2021
Module coordinator:	Heads of the degree programme
Lecturer:	acc. selected module
Language:	German or English
Place in curriculum:	Elective: The choice of the students has to be confirmed by the study program coordinators to avoid clashes with core subjects and to ensure the fitting to the study program.
Timetabled hours:	Recommended: 4 HPW
Workload:	acc. module description
Credits:	5
Recommended prerequisites:	none
Module objectives:	acc. module description of the selected module
Content:	acc. module description of the selected module
Assessment:	acc. module description of the selected module
Forms of media:	acc. module description of the selected module
Literature:	acc. module description of the selected module

2300 Introduction to Electrical Engineering

Module name/Module code:	Introduction to Electrical Engineering 2300
Degree:	Electrical and Electronics Engineering: EL 1 2300
Module coordinator:	Heads of Study Programm
Lecturer:	Prof. Dr.-Ing. G. Gehnen Prof. Dr. G. Bastian A. Viermann
Language:	English
Place in curriculum:	Core
Timetabled hours:	Descriptive Statistics and Reporting: Lecture: 1HPW Basics of Communication and Self-Management: Seminar: 1 HPW Experience with Electrical Engineering: Seminar: 1 HPW
Workload:	Descriptive Statistics and Reporting: 15 h attendance 15 h preparation Basics of Communication and Self-Management: 15 h attendance 15 h preparation and self study Experience with Electrical Engineering: 15 h attendance 15 h_preparation and self study
Credits:	3
Recommended prerequisites:	none
Module objectives:	Descriptive Statistics and Reporting: • Students learn to present, summarize, and interpret data in a meaningful way. They learn to present data graphically using standard software packages. The focus lies on enabling the students to handle experimental data in future lab reports. Basics of Communication and Self-Management: • Getting to know and apply helpful first basic knowledge, methods and strategies in order to build up skills and capabilities to succeed in studying, communicating and working together with others. • Supporting with adequate exercises and team building elements the team building processes within the study courses in the first semester. On this base, reflect on the experiences and proceedings in order to learn from it for other transferable settings in teams and organizations. Experience with Electrical Engineering: • Make the students familiar with real components and the way to handle that components in a real circuit

	• The students should be able to create some easy circuit starting from the circuit diagram to the final layout and a working prototype in the end
Content:	Descriptive Statistics and Reporting: • sample vs. population • grouping data • Median, quartiles, percentiles • Standard units (z-score), bivariate data, scatter plot • Regression – least squares • Report writing • Error propagation Basics of Communication and Self-Management: • Communication and Conflict Management • Learning and Self-Management • Dealing with Stress • Working Together Experience with Electrical Engineering: • Design of an Electric circuit • Conversion from a diagram to a real circuit • Soldering tutorial
Assessment:	Attestation
Forms of media:	Webex/Moodle
Literature:	Reporting and Descriptive Statistics: 1. Devore, J. (2012). *Probability and Statistics for Engineering and the Sciences* (8th edition Ausg.). Boston: Brooks/Cole. 2. Mittal, H. V. (2011). *R Graphs Cookbook.* Brimingham - Mumbai: Packt Publishing Basics of Communication and Self-Management: 1. Different literature related to the different topics as well as additional learning material will be provided during class. Experience with Electrical Engineering: 1. Different literature related to the different topics as well as additional learning material will be provided during class.

2301 Electrical Engineering I

Module name/Module code:	Electrical Engineering I	2301
Degree:	Electrical and Electronics Engineering	EL 1 2301
Module coordinator:	Prof. Dr.-Ing. G. Gehnen	
Lecturer:	Prof. Dr.-Ing. G. Gehnen	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise: Practical Training:	2 HPW 1 HPW 1 HPW
Workload:	75 h attendance 35 h preparation and review 40 h exam preparation	
Credits:	5	
Recommended prerequisites:	School knowledge in Physics and Mathematics	
Module objectives:	Students are able to apply the fundamental laws of Electrical Engineering. They know the dangers originating from electric current. They are able to analyse networks of passive linear components as well as to calculate currents and potential differences in these networks. They are able to calculate transient processes with capacitors and inductances by means of ordinary differential equations. They can analyse a static electric field as a vector field, and can calculate the electrical potential as a property of the vector field. They are able to analyse simple electric flow fields and to calculate resistances from first principles. Students are able to apply and validate the learned methods using simulations. The learnt abilities are trained and tested in an accompanying exercise and in the lab.	
Content:	• General introduction to Electrical Engineering, historical background • Electrostatics: atoms, electrons and charge • Coulomb's law • Current as charge movement • Electric potential and voltage • Resistors, Ohm's law • Electrical safety • Resistors in parallel and series • Kirchhoff's laws • Mesh Analysis • Electric power and energy • Superposition principle • Thevenin's theorem, equivalent sources • Fundamentals of capacitors • Transient processes in capacitors • Induction • Inductors and their analogy to capacitors • Transient processes in inductors	

	• Circuit simulation with SPICE • Stationary electrical flow fields
Assessment:	Attestation within the scope of laboratory; Written examination
Forms of media:	Webex/Moodle
Literature:	1. R.L. Boylestad: Introductory Circuit Analysis, 12th edition, Pearson, 2010 Further Readings: 2. G. Hagmann: Grundlagen der Elektrotechnik (Fundamentals of Electrical Engineering), 15th edition, AULA Verlag, 2011 3. G. Hagmann: Aufgabensammlung zu den Grundlagen der Elektrotechnik (Set of exercises regarding Fundamentals of Electrical Engineering), 14th edition, AULA Verlag, 2010 4. Course materials from the lecturer 5. Laboratory documents and exercises from the lecturer

2302 Electrical Engineering II

Module name/Module code:	Electrical Engineering II 2302
Degree:	Electrical and Electronics Engineering: EL 2 2302
Module coordinator:	Prof. Dr.-Ing. G. Gehnen
Lecturer:	Prof. Dr.-Ing. G. Gehnen
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	75 h attendance 35 h preparation and review 40 h exam preparation
Credits:	5
Recommended prerequisites:	2301 Electrical Engineering I
Module objectives:	Students have knowledge of alternating current circuits and can calculate currents, potential differences and impedances with complex numbers. In doing so they are able to calculate the frequency-dependent behaviour of a circuit. Also they are familiar with three-phase circuits and star-delta transformations.
Content:	• Fundamentals of AC circuit engineering • Calculating with complex numbers in AC circuit engineering, pointer indication • Root mean squares and peak values • Calculation of impedance and admittance • Networks in complex notation, phasor • Energy and power in AC networks • Frequency-dependent behaviour • Three phase networks • Triangle and star circuits • Transformation of three phase systems
Assessment:	Attestation within the scope of laboratory; Written examination
Forms of media:	Whiteboard, PowerPoint, Projector, Simulation programs, demonstration during lecture, laboratory equipment
Literature:	1. R.L. Boylestad: Introductory Circuit Analysis, 12th edition, Pearson, 2010 2. G. Hagmann: Fundamentals der Elektrotechnik (Fundamentals of Electrical Engineering), 15th edition, AULA Verlag, 2011 Further Readings:

	3. G. Hagmann: Aufgabensammlung zu den Grundlagen der Elektrotechnik (Set of exercises regarding Fundamentals of Electrical Engineering), 14th edition, AULA Verlag, 2010 4. Course materials from the lecturer 5. Laboratory documents and exercises from the lecturer

2303 Digital Electronics

Module name/Module code:	Digital Electronics 2303
Degree:	Electrical and Electronics Engineering EL 2 2303 Mechatronic Systems Engineering MSE 4 2303
Module coordinator:	Prof. Dr. R. Hartanto
Lecturer:	Prof. Dr. R. Hartanto
Language:	English
Place in curriculum:	Core: EL Focus Field Subject: MSE
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	90 h attendance 30 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	2301 Electrical Engineering I
Module objectives:	After successful completion of this module, students able to • perform binary arithmetic • create circuits to add and subtract binary numbers using logic gates and the theorems of Boolean algebra • aided by Karnaugh maps, they can create logic functions according to requirements and assemble them in specific links • simplify or represent digital circuits using equivalent logic gates • create typical combinational circuits and storage circuits for technical applications • analyse VHDL program • create and design digital circuits using FPGA with VHDL • recognize the typical characteristics of digital circuits which use TTL and CMOS circuit techniques
Content:	• The numeric system in binary representation • Digital addition and subtraction • Logic gates and switching algebra • Karnaugh maps • Technical realisation of digital circuits • TTL and CMOS • Combinational circuits • Asynchronous and synchronous circuit engineering • Storage circuits • FPGA programming using VHDL
Assessment:	Lecture: Written examination Practical Training and Exercise: Attestation

Forms of media:	Whiteboard, PowerPoint, Projector, Laboratory experiments
Literature:	1. T. Floyd: Digital Fundamentals, a systems approach, Pearson, 2012 Further Readings: 2. Klaus Fricke: Digitaltechnik (Digital Technology), Vieweg+ Teubner, 2009 3. Jan M. Rabaey, Digital Integrated Circuits, Prentice Hall, 2002 4. Ronald J. Tocci: Digital Systems: Principles and Applications, Prentice Hall, 2010 5. John F. Wakerly: Digital Design: Principles and Practices, Addison Wesley, 2006

2304 Analog Electronics

Module name/Module code:	Analog Electronics 2304
Degree:	Electrical and Electronics Engineering: EL 2 2304 Mechatronic Systems Engineering: MSE 2 2304
Module coordinator:	Prof. Dr.-Ing. G. Gehnen
Lecturer:	Prof. Dr.-Ing. G. Gehnen Prof. Dr. R. Hartanto
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 50 h preparation and review 40 h exam preparation
Credits:	5
Recommended prerequisites:	2301 Electrical Engineering I
Module objectives:	Students know the fundamental conduction mechanisms in semiconductors and the effects that occur by connecting different types of semiconductors. Based on this, they can describe the functional principle of diodes and transistors. They master the basic circuits of diodes and transistors and are able to calculate the proportions of current and voltage using curves and empirical formulae. They are able to design and to analyse circuits containing operational amplifiers. They know the frequency behaviour of semiconductor components and operational amplifiers and are therefore able to make corresponding assessments for practical application. Based on this knowledge, students are able to estimate the frequency behaviour of circuits as well as to apply the related effects specifically for the operation of oscillating circuits.
Content:	• Semiconductors: Structure and conduction mechanisms • Doping of semiconductors • p-n junction and diodes • Applications of diodes • Special forms of diodes: Z-diodes, Schottky-diodes, LEDs • Bipolar transistors, fundamentals and characteristics • Basic transistor circuits • Field effect transistors • Fundamentals of operational amplifiers • Op amp circuits • Frequency-dependent behaviour: Oscillators, timers, and filters • Voltage conversion with linear control systems and clocked circuits

Assessment:	Attestation within the scope of laboratory; Written examination
Forms of media:	Whiteboard, PowerPoint, Projector, Simulation programs, demonstration during lecture, laboratory equipment
Literature:	1. R. L. Boylestad, L. Nashelsky: Electronic Devices and Circuit Theory, 10th edition, Pearson, 2009 2. Horowitz, Hill: The Art of Electronics 3rd edition, Cambridge University Press; 2015 Further Readings: 3. M. Rashid: Microelectronic Circuits, 2nd edition, Cengage Learning, 2011 4. Tietze, Schenk: Halbleiterschaltungstechnik (Semiconductor circuit Technology), Springer Verlag, 2009 5. Course materials from the lecturers 6. Laboratory documents and exercises from the lecturers

2306 Microcontrollers

Module name/Module Code:	Microcontrollers 2306
Degree:	Electrical and Electronics Engineering: EL 3 2306 Mechatronic Systems Engineering: MSE 3 2306
Module coordinator:	Prof. Dr.-Ing. I. Volosyak
Lecturer:	Prof. Dr.-Ing. I. Volosyak
Language:	English
Place in curriculum:	Core subject
Timetabled hours:	Lectures: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 50 h preparation and review 40 h exam preparation
Credits:	5
Recommended prerequisites:	2011 Programming 2012 Advanced Programming 2301 Electrical Engineering I 2302 Electrical Engineering II 2303 Digital Electronics
Module objectives:	Based on data types bit and byte, students master the typical data representation in microcontrollers. They can label the elements of a microcontroller according to Harvard architecture and show the procedural structures for command processing. They are able to write microcontroller instructions using addressing schemes and the set of commands. They can control data input and output and they know the essential development tools for creating programs for microcontrollers (C programming language).
Content:	• Data representation in bits and bytes • Princeton and Harvard architecture • CPU components • Instruction coding and addressing • Data storage • Input and output systems • Development tools
Assessment:	Attestation within the scope of laboratory (T), Written examination (P)
Forms of media:	Webex/Moodle, Laboratory experiments on campus
Literature:	1. E. Williams: Make: AVR Programming, O'Reilly and Associates, 2014. Also available as online resource: http://www.digibib.net/permalink/1383/FHBRHW-x/HBZ:HT019887239 2. T. Floyd: Digital Fundamentals, a systems approach, Pearson, 2012

	3. S. Barret: Embedded Systems Design with the Atmel AVR Microcontroller, Morgan & Claypool Publishers, 2009 Further reading: 4. J. Sanchez: Microcontroller Programming [The Microchip PIC], CRC Press, 2007 5. Klaus Fricke: Digitaltechnik (Digital Technology), Vieweg+ Teubner, 2009 6. Jan M. Rabaey, Digital Integrated Circuits, Prentice Hall, 2002 7. Ronald J. Tocci: Digital Systems: Principles and Applications, Prentice Hall, 2010 8. John F. Wakerly: Digital Design: Principles and Practices, Addison Wesley, 2006 9. Ioan Susnea, Marian Mitescu: Microcontrollers in Practice, Springer, 2006 10. N. Senthil Kumar, M. Saravanan, S. Jeevananthan: Microprocessors and Microcontrollers, Oxford University Press, 2011

2307 Fields and Waves

Module name/Module code:	Fields and Waves 2307
Degree:	Electrical and Electronics Engineering: EL 3 2307
Module coordinator:	Prof. Dr. A. Struck
Lecturer:	Prof. Dr. A. Struck
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lectures: 2 HPW Exercises: 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	2003 Physics 2000 Introductory Mathematics 2001 Applied Mathematics 2301 Electrical Engineering I 2302 Electrical Engineering II
Module objectives:	• to understand electric and magnetic fields and their mathematical description • aquire elementary skills in volume, surface and line integrals • calculating electromagnetic fields in various geometries relevant for practical problems •
Content:	• Scalar and vector fields • Fundamentals of vector analysis • Differential operators div, rot, grad • Line, surface and volume integrals • Electric and Magnetic fields • Maxwell's equations of electrodynamics • Electrostatics and Magnetostatics • Time-dependent problems, waves •
Assessment:	Written examination or oral examination
Forms of media:	Webex/Moodle
Literature:	1. Edward M. Purcell, David J Morin: Electricity and Magnetism, 3rd edition, Cambridge University Press, 2013 2. Daniel Fleisch: A Student's Guide to Maxwell's Equations, Cambridge University Press, 2008 3. Daniel Fleisch, Laura Kinnaman, A Student's Guide to Waves 4. all introductory text used in Fundamentals of Physics, Introductory and Applied Mathematicsss

2308 Signal Transmission

Module name/Module code:	Signal Transmission 2308
Degree:	Electrical and Electronics Engineering: EL 3 2308 Mechatronic Systems Engineering: MSE 5 2308
Module coordinator:	Prof. Dr. A. Stamm
Lecturer:	Dr. E. Goldschmidt (external Lecturer) F. Kremer
Language:	English
Place in curriculum:	Core (EL), Focus Field Subject (MSE)
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	2000 Introductory Mathematics 2001 Applied Mathematics 2304 Analog Electronics 2301 Electrical Engineering I 2301 Electrical Engineering II
Module objectives:	After finishing this module, students master the differences between continuous and discrete-time signals. Students understand the time- and frequency domain of signals and their essential applications in communications engineering. They know the characteristics of linear time-invariant systems for continuous and discrete signals. The common transformations needed for calculating communication transmissions are comprehensively mastered by the students.
Content:	• Fundamentals of continuous and discrete signals and systems • Sampling theorem • Fourier transforms and their applications • Laplace transforms • Linear time-invariant systems • Z-transformation • Applications in communication systems • Terminology of information theory: entropy, redundancy, decision content • Basics of source coding, channel coding and modulation
Test/examination results:	Written examination and Lab Reports
Forms of media:	Webex/Moodle
Literature:	1. Alan Oppenheim, Alan Willsky, with Hamid: Signals and Systems, 2. Ed., Pearson International, 2014

	2. Robert G. Gallager: Principles of Digital Communication, Cambridge University Press, 2008 Further Readings: 3. Christoph Arndt: Information Measures: Information and its Description in Science and Engineering, Springer, 2003 4. Wolfgang Frohberg, Horst Kolloschie, Helmut Löffler: Taschenbuch der Nachrichtentechnik (Pocket book of Communications Engineering), Carl Hanser Verlag, 2008 5. Christoph Arndt: Information Measures: Information and its Description in Science and Engineering, Springer, 2003 6. Charles Phillips, John Parr, Eve Riskin: Signals, Systems, and Transforms, Pearson International, 2008 7. Yuriy Shmaliy: Continuous-Time Signals, Springer, 2006 John G. Proakis: Digital Communications, McGraw-Hill, 2000 8. Martin Werner: Information und Codierung: Fundamentals und Anwendungen (Information and Coding: Fundamentals and Applications), Vieweg und Teubner, 2008

2309 Object Oriented Programming

Module name/Module code:	Object Oriented Programming 2309
Degree:	Electrical and Electronics Engineering: EL 3 2309 Mechatronic Systems Engineering: MSE 5 2309
Module coordinator:	Prof. Dr. M. Krauledat
Lecturer:	Prof. Dr. R.Hartanto
Language:	English
Place in curriculum:	Core: EL Focus Field Subject: MSE
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	2012 Advanced Programming
Module objectives:	After successfully finishing the module, students are able to • develop small programs with object-oriented design • analyze program code that has been created in an object-oriented manner • transfer technical problems into an object-oriented design and to describe them in UML
Content:	Programming • Introductory Programming • Introduction to the concept of object-oriented programming • Program development tools • Control flow and control structures • Pointer and references • Functions in OOP • Classes • Interfaces • Inheritance • Polymorphism • Abstract data types (ADT) • Enumerations and Collections • Input, output and streams • Name ranges and visibility • Object-oriented analysis • Object-oriented design, UML • Design Patterns • Treatment of errors and exceptions • Applications on different operating systems (such as Windows or *nix) • Examples and practical programming exercises by means of a concrete object-oriented programming language (such as: C++, JAVA, Python)

Assessment:	Graded: Continuous assessment (10%: homework or quizzes) and written or oral examination (90%)
Forms of media:	Webex/Moodle
Literature:	1. D. Flanagan : Java in a Nutshell: A Desktop Quick Reference, O'Reilly, 2005, ISBN: 978-0596007737 2. S. Oualline: Practical C++ Programming, O'Reilly, 2003, ISBN: 978-0596004194 3. D. Boles, C. Boles: Objektorientierte Programmierung spielend gelernt, Vieweg&Teubner, 2. Auflage, 2010 4. Y.D. Liang: Introduction to Java Programming and Data Structures 10 or 11 ed, Pearson, 2019.

2310 Signal Processing & Measurement Technology

Module name/Module code:	Signal Processing & Measurement Technology 2310
Degree:	Electrical and Electronics Engineering: EL 4 2310
Module coordinator:	Prof. Dr. A. Stamm
Lecturer:	NN External Lecturer
Language:	English
Place in curriculum:	Core
Timetabled hours:	<u>Measurement Technology</u> Practical Training: 2 HPW <u>Signal Processing</u> Lecture: 1 HPW Exercise: 1 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	2308 Signal Transmission
Module objectives:	<u>Analog Measurement Technology:</u> Students are able to describe the structure of a measuring chain from the physical feature to a sensor up to an abstract electrical representation. They master the methods of error computation necessary for estimating the characteristics of the measuring device. Students are familiar with causes of error and the constructive design of signal processing. They know a set of typical sensors and are able to deduce fundamental sensor principles even for new applications. <u>Digital Signal Processing:</u> Students master the important methods of signal processing and their theoretical fundamentals. Regarding the objective of an application such as signal improvement or signal compression, they are able to critically assess the methods and recognise alternatives. They are able to apply these methods to time-dependent signals.
Content:	<u>Analog Measurement Technology:</u> • Basic terminology of Measurement Technology • Parameters of signals, representation of values • Measuring chain and fault effects • Measurement methods • Typical sensors in practical applications • Sensor interfaces <u>Digital Signal Processing:</u> • Analog and digital signals, digitisation of signals • Sampling theorem • Stochastic signals • Correlation methods

	• Analysis in the Frequency domain • Time-discrete signals, linear time-discrete systems • Discrete Fourier transforms, scanning and windowing • Digital filters, IIR and FIR filter
Assessment:	Continuous Assessment and Written examination
Forms of media:	Whiteboard, PowerPoint, Projector, Lab Documents
Literature:	Analog Measurement Technology: Jon Wilson, Sensor Technology Handbook, Newnes, 2004 Jacob Fraden: Handbook of modern Sensors, Springer, 2010 Digital Signal Processing: Oppenheim, Schafer, Buck: Discrete-Time Signal Processing, 3rd ed., Pearson, 2014 Further Readings: DIN 1319: Grundlagen der Messtechnik (Fundamentals of Measurement Technology) Thomas Mühl: Introduction to electrical Measurement Technology; Vieweg und Teubner, 2008 D. Ch. von Grünigen: Digitale Signalverarbeitung (Digital Signal Processing), Carl Hanser, 2008 M. Werner: Digital Signal Processing with MATLAB Vieweg+Teubner, 2008 Steven Smith: Digital Signal Processing. A Practical Guide for Engineers and Scientists, Newnes, 2002 John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing, Pearsons, 2002

2311 Embedded Systems

Module name / Module code:	Embedded Systems 2311
Degree:	Electrical and Electronics Engineering: EL 4 2311 Mechatronic Systems Engineering: MSE 4 2311
Module coordinator:	Prof. Dr. A. Stamm
Lecturer:	Prof. Dr. A. Stamm
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	2306 Microcontroller 2309 Object oriented Programming
Module objectives:	Students have a broad knowledge of embedded systems for which the boundary conditions of limited resources and hardware dependencies are valid. In particular, they know the processes of modern embedded systems development. They are able to differentiate embedded systems from cyber-physical systems. Students should be able to name different motivations and the importance of embedded systems in nowadays technology and life of humans. They are able to conceptual understand the hardware development process of embedded systems. They are able to apply a typical design flow during embedded system development. This will include model definitions, requirements for a model, models of computation, models of communications, and combined models. Students understand concepts for testing embedded software. They are able to write software for embedded systems including the practical implementation and testing of that software on an embedded system. This includes cross/compiling of C Programs. Students are able to specify suitable embedded systems for a given task, to create a suitable software concept for this and to select necessary tools and test environments. They act in a methodical and structured manner in this regard, and use professional tools. Students who have finished this module successfully understand how embedded systems are integrated in an overall system.
Content:	• Characteristics of Embedded Systems • Architecture of Embedded Systems • Challenges during the design phase of Embedded Systems • Real time behaviour, soft and hard real time

	• Design flow • Specifications & Modeling (CFSM, StateCharts, Petri nets) • Event based languages • Von-Neumann model • Comparison of different models • Modeling levels • Embedded Systems Hardware • Embedded Systems Software • Evaluation and Validation • Program implementation: booting, cross-compiling, linking, loading, remote debugging • Hardware abstraction • Failure safety
Assessment:	Written examination
Forms of media:	Whiteboard, PowerPoint, Projector, Laboratory experiments
Literature:	1. P. Marwedel: Embedded System Design, Springer, 2011 2. Qing Li, Caroline Yao: Real-Time Concepts for Embedded Systems. CMP Books, 2003. Further Readings: 3. A. Forrai: Embedded Control System Design [A model driven approach], Springer, 2013 4. Frank Vahid and Tony Givargis: Embedded System Design: A Unified Hardware/Software Introduction. John Wiley & Sons, 2002 5. Arnold S. Berger: Embedded Systems Design. CMP Books, 2001.

2312 Microelectronic Control Systems

Module name/Module code:	Microelectronic Control Systems 2312
Degree:	Electrical and Electronics Engineering: EL 5 2312
Module coordinator:	Prof. Dr.-Ing. I. Volosyak
Lecturer:	Prof. Dr.-Ing. I. Volosyak
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lectures: 2 HPW Exercise: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 50 h preparation and review 40 h exam preparation
Credits:	5
Recommended prerequisites:	2306 Microcontrollers 2902 System Theory and Controls
Module objectives:	After completing this module, students are able to design the architecture of microelectronic controls. They are able to select corresponding components and to evaluate them for application. They master the essential aspects of microcontroller-based control systems in hardware and software and are able to interpret them corresponding to relevant principles. Students are familiar with key technologies for realising modern control systems such as networks, real time systems and modern interactive interfaces. They are able to create analyses of the expected requirements and to select corresponding systems.
Content:	• Architecture of control systems • Components of microelectronic controls • Security aspects in designing control systems • Safety-oriented programming • Safety-oriented hardware • Object-oriented programming in Automation engineering • Distributed controls • The concept of real time • Graphical user interface
Assessment:	Attestation within the scope of laboratory (T)
Forms of media:	Webex/Moodle, Laboratory experiments on campus
Literature:	1. E. Williams: Make: AVR Programming, O'Reilly and Associates, 2014. Also available as online resource: http://www.digibib.net/permalink/1383/FHBRHW-x/HBZ:HT019887239

	2. S. Barret: Embedded Systems Design with the Atmel AVR Microcontroller, Morgan & Claypool Publishers, 2009 3. Nobuyasu Kanekawa, Eishi H. Ibe, Takashi Suga, Yutaka Uematsu: Dependability in Electronic Systems: 4. Mitigation of Hardware Failures, Soft Errors, and Electro-Magnetic Disturbances, Springer, 2010 5. Course materials from the lecturer

2314 Practical Electronics

Module name / Module code:	Practical Electronics 2314
Degree:	Electrical and Electronics Engineering: EL 5 2314 Mechatronic Systems Engineering: MSE 5 2314
Module coordinator:	Prof. Dr. A. Stamm
Lecturer:	Prof. Dr. A. Stamm
Language:	English
Place in curriculum:	Core: EL Focus Field Subject: MSE
Timetabled hours:	Lecture: 2 HPW Exercise: 1HPW Practical Training: 1 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	2306 Microcontroller
Module objectives:	Students will be able to design electronic circuits and implement these as printed circuit boards. It involves PCB design, system and component specification, and design principles including noise reduction, transducers, ergonomics, power supplies, and design for testability. Students are required to complete a practical PCB design and a paper system design as part of their assessment.
Content:	Lecture: • Introduction to circuit design principles • Op-amps • Rectifiers • Resistors, capacitors, inductors • Transformers • PCB design and fabrication • Sensors and transducers • Identifying noise sources and reduction Project: • Students will be meeting their group members outside of lectures and labs to discuss and decide on a project • Each group of students will be required to propose their project and their circuit to the whole class with oral feedback given by the teaching team (10 minutes) • Students have to prepare a presentation and a written report which will be part of the assessment • Students will present the outcomes in class (15 minutes) •

	Labs: • Students will be required to attend the labs and design the desired circuit using a PCB Design software • Software training will be provided in class • Implementation of the developed PCB • Assembly of electronic components on the PCB • Development of software for project related tasks (if necessary) • Presentation of a working prototype
Assessment:	Continuous assessment (graded)
Forms of media:	Webex/Moodle, Laboratory experiments digital and on campus
Literature:	Notes supplied during lecture and labs Peter Wilson and Tim Williams, *The circuit designer's companion*, Elsevier, 2004

2315 Low Power Design

Module name/Module code:	Low Power Design 2315
Degree	Electrical and Electronics Engineering: EL 4 2315
Module coordinator:	Prof. Dr.-Ing. G. Gehnen
Lecturer:	Prof. Dr.-Ing. G. Gehnen
Language:	English
Place in curriculum:	Focus Field Subject
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW
Workload:	45 h attendance 45 h preparation and review 45 h exam preparation
Credits:	5
Recommended prerequisites:	2311 Embedded Systems
Module objectives:	Based on the fundamentals of electronic circuit engineering, students are able to name the cause of power consumption and choose measures to minimise power consumption depending on circuit type and area of application. They master design methods to avoid power consumption early on during the design process. They are familiar with the susceptibility to interference of power-optimised circuits. Students are able to select suitable methods from common energy harvesting methods, and apply them, with due consideration of load profiles and production potentials.
Content:	• Causes of power consumption of electronic circuits • Performance optimisation of Analogue circuits • Reduction of power consumption of digital circuits • Processor based systems and their software • Sensitivity towards disturbances • Energy Harvesting • Case Studys
Assessment:	Written or oral examination
Forms of media:	Whiteboard, PowerPoint, Projector, Demonstation
Literature:	1. John Rabaey, Low Power Design Essentials, Springer, 2009 2. Nihal Kularatna: Power Electronics Design Handbook: Low-Power Components and Applications: Low-power Components and Applications, Newnes, 1998 Further Readings: 3. Nianxiong Nick Tan, Zhihua Wang, Dongmei Li: Ultra-Low Power Integrated Circuit Design: Circuits, Systems, and Applications, Springer, 2011

	4. Laurie Kelly, Piguet Piguet, Christian Piguet: Low-Power Electronics Design, Crc Pr. 2005

2316 Design of Environmentally friendly Circuits & Recycling of Electronics

Module name / Module code:	Design of Environmentally friendly Circuits & Recycling of Electronics 2316
Degree:	Electrical and Electronics Engineering: EL 4 2316
Module coordinator:	Prof. Dr. A. Stamm
Lecturer:	External Lecturer
Language:	English
Place in curriculum:	Focus Field Subject
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW
Workload:	45 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	
Module objectives:	Students know the life cycle of electronic devices and are able to name the requirements resulting from rules such as IEC 62430. They are able to classify and optimise the design process by means of the energy consumption aspects in the company, the necessary resources for production and disposal. Students understand the production processes of many different components used in electronic products and are able to understand the complexity of new electronic products. They are familiar with proper recycling methods used to recycle end-of-life electronic products and how to design product in the way of optimal recycling later on.
Content:	• Life cycle of electronic devices • Standards and regulations for the design: IEC 62430 • Raw materials and their production • Production of electronic components • Operational energy consumption • Recycling and environmentally sound waste disposal
Assessment:	Written examination
Forms of media:	Whiteboard, PowerPoint, Projector
Literature:	1. Sammy G. Shina, Green Electronics, 2008 (Library: 00/XVU 2) 2. Wolfgang Wimmer et al.: ECODESIGN -- The Competitive Advantage, Springer, 2010 (Library: 00/PWP 30)

2317 Optoelectronics

Module name/Module code:	Optoelectronics 2317
Degree:	Electrical and Electronics Engineering: EL 5 2317
Module coordinator:	Prof. Dr. G. Bastian
Lecturer:	Prof. Dr. G. Bastian
Language:	English
Place in curriculum:	Focus Field Subject
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW
Workload:	45 h attendance 45 h preparation and review 45 h exam preparation
Credits:	5
Recommended prerequisites:	
Module objectives:	Students have a general view of the conversion of light into electronic signals and vice versa. They are able to classify and evaluate optoelectronic components with regard to occurring effects, functions, specifications and areas of application. Students therefore have the skill to dimension and use optoelectronic components in complete systems.
Content:	The lecture starts with the fundamentals of optics and semiconductor physics. The application-related main part is structured in optical signal generation (LED, laser, displays) on the one hand and optical receivers (photodiodes, detector types, solar cells) on the other hand.
Assessment:	Written or oral examination
Forms of media:	Moodle
Literature:	1. Course materials from the lecturer 2. Physics of photonic devices, S. L. Chuang, Wiley (2009)

2318 Nanoelectronics

Module name/Module code:	Nanoelectronics 2318
Degree:	Electrical and Electronics Engineering: EL 5 2318
Module coordinator:	Prof. Dr. G. Bastian
Lecturer:	Prof. Dr. G. Bastian
Language:	English
Place in Curriculum:	Focus Field Subject
Timetabled hours:	Lecture: 2 HPW Exercise: 1 HPW
Workload:	45 h attendance 75 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	2308 Signal Transmission 2310 Signal Processing & Measurement Technology
Module objectives:	Students know the effects of quantum mechanics, which matter at advanced miniaturisation. They master the basic mathematical relationships. They are able to describe the impacts of effects on circuit techniques and to select sensor systems based on these effects. They know single electron effects and spintronical effects and the related circuit techniques.
Content:	• Transition from micro to nanoelectronics • Quantum mechanical effects • Basic structures of nanoelectronics • Fabrication methods of different structures • Applications of quantum effects in nanoelectronics • Quantum computer
Assessment:	Written or oral examination
Forms of media:	Moodle
Literature:	1. R. Waser (ed.), Nanoelectronics and Information Technology, Wiley-VCH, 2003 2. S. Datta, Electron Transport in Mesoscopic Systems, Cambridge University Press, 1995 Further Readings: 3. D.K. Ferry and S.M. Goodnick, Transport in Nanostructures, Cambridge University Press, 1997 4. C.W.J. Beenakker & H. van Houten, in: Solid State Physics, eds. H. Ehrenreich & D. Turnbull, vol. 44, Academic Press, 1991

	5. Y. Imry, Introduction to Mesoscopic Physics, Oxford University Press, 1997 T. Dittrich et al., Quantum Transport and Dissipation, Wiley-VCH, Weinheim, 1998 Course materials from the lecturer

2319 Mobile Information Devices

Module name / Module Code:	Mobile Information Devices 2319
Degree:	Electrical and Electronics Engineering: EL 4 2319
Module coordinator:	Prof. Dr. A. Stamm
Lecturer:	Prof. Dr. A. Stamm
Language:	English
Place in curriculum:	Focus Field Subject
Timetabled hours:	Lecture: 2 HPW Practical Training: 1 HPW
Workload:	45 h attendance 75 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	2306 Microcontroller 2309 Object oriented programming
Module objectives:	Students are able to name the special aspects in the design of mobile devices for information transmission. They master the characteristics of the most important battery technologies and the necessary charging circuits. They know modern communication interfaces and systems for determining the position of a device. Students are able to evaluate different technologies for interacting with the user and select and combine them for specific tasks. Students know important operating systems and their characteristics for creating application software running on mobile devices.
Content:	• Features of mobile devices • Battery and charging technology • Communication interfaces • Location awareness • User interface • Operating systems and application software • Cloud
Assessment:	Written examination
Forms of media:	Whiteboard, PowerPoint, Projector
Literature:	1. Axel Küpper: Location-Based Services, Wiley, 2005 2. B.J. Fogg, Persuasive Technology, Morgan Kaufmann, 2003 3. Athanasios Vasilakos , Witold Pedrycz: Ambient Intelligence, Wireless Networking, and Ubiquitous Computing, Artech House Inc., 2006

2320 Audio and Speech Processing

Module name/Module code:	Audio and Speech Processing 2320
Degree:	Electrical and Electronics Engineering: EL 4 2320
Module coordinator:	Prof. Dr. M. Krauledat
Lecturer:	Prof. Dr. M. Krauledat
Language:	English
Place in curriculum:	Focus Field Subject
Timetabled hours:	Lecture: 2 HPW Practical Training: 1 HPW
Workload:	45 h attendance 45 h preparation and review 30h exam preparation
Credits:	5
Recommended prerequisites:	2308 Signal Transmission
Module objectives:	Students master the characteristics of audio signals and their representation in digital systems. They are able to design suitable methods for input, processing and output of audio signals with available resources, within given quality parameters. Students are familiar with the acoustic characteristics of human language. Using these characteristics, they are able to design and apply compression systems as well as synthesised speech.
Content:	• Basic characteristics of audio signals • Representation of audio signals in digital systems • Recording and playback • Characteristics of speech signals • The human ear and its characteristics • Audio analysis • Audio synthesis • Speech processing • Compression of speech and audio
Assessment:	Written or oral examination, laboratory reports
Forms of media:	Whiteboard, PowerPoint, Projector, Practical experiments
Literature:	1. Ian McLoughlin, Applied Speech And Audio Processing: With Matlab Examples, Cambridge University Press, 2009 2. Proakis, Digital Signal Processing, Prentice Hall, 2008 3. U. Zölzer, Digital Audio Signal Processing, John Wiley & Sons, 2008 Further Readings: 4. Peter Vary, Rainer Martin, Digital Speech Transmission, John Wiley & Sons, 2006 5. Course materials from the lecturer

2321 Biomedical Electronics

Module name/Module code:	Biomedical Electronics 2321
Degree	Electrical and Electronics Engineering: EL 5 2321
Module coordinator:	Prof. Dr.-Ing. I. Volosyak
Lecturer:	Prof. Dr.-Ing. I. Volosyak
Language:	English
Place in curriculum:	Focus Field Subject
Timetabled hours:	Lectures: 2 HPW Exercise: 2 HPW
Workload:	60 h attendance 50 h preparation and review 40 h exam preparation
Credits:	5
Recommended prerequisites:	2310 Signal Processing and Measurement Technology
Module objectives:	Students know the fundamentals of electric potential within the human body that can be measured by ECG or EEG for example. They know a selection of sensors supporting different diagnostic processes, by which they are able to select and specify sensor systems for these areas of application. They master basic methods of image processing as used in tomography, for example. The students understand the fundamentals of electrical potentials in the human brain which can be detected with non-invasive and invasive methods. They can derive, from first principles, real architectures for modern Brain-Computer Interfaces. They are aware of the legal and other requirements for medical products and based on this, they are able to estimate which constructive measures are necessary. A brief introduction to implantology allows students to recognise the limits and possibilities of implanting electronic components for supporting sensory and actuatory functions.
Content:	• The body as an electric system • EKG, EEG • Brain-Computer Interfaces • Sensor systems for medical applications • Introduction to image-processing systems • Requirements for medical products • Implantable electronics
Assessment:	Written examination (P)
Forms of media:	Webex/Moodle, Training on campus
Literature:	1. L. Street: Introduction to Biomedical Engineering Technology, 2nd edition, CRC Press, 2011

	2. W. Saltzmann: Biomedical Engineering, Cambridge University Press, 2009 3. M. Culjat: Medical Devices, Wiley, 2013 Further reading: J. Enderle: Introduction to Biomedical Engineering, Academic Press, 2011 R. Northrop: Analysis and Application of analog electronic circuits to biomedical instrumentation, CRC Press, 2012 Bronzino, Joseph D.: The Biomedical Engineering Handbook, CRC Press, 2006 G. Schalk, A practical Guide to Brain-Computer Interfacing with BCI2000, Springer, 2010 J. Wolpaw, E. Wolpaw, Brain-Computer Interfaces: Principles and Practice, Oxford Univ Pr, 2012

2322 Networks in Industrial Automation

Module name/Module code:	Networks in Industrial Automation 2322
Degree	Electrical and Electronics Engineering: EL 5 2322
Module coordinator:	Prof. Dr. A. Stamm
Lecturer:	NN External Lecturer
Language:	English
Place in curriculum:	Focus Field Subject
Timetabled hours:	Lecture: 1 HPW Exercise: 1 HPW Practical Training: 2 HPW
Workload:	60 h attendance 30 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	2308 Signal Transmission 2310 Signal Processing & Measurement Technology
Module objectives:	Students master the basic concepts of bus systems. They are able to distinguish different methods of bit transmission via physical layer and different medium access control mechanisms. Students have knowledge of typical bus systems in industrial automation. They are able to classify the advantages and disadvantages of different bus systems and select suitable bus systems for different cases of application. They are aware of the influence of the Quality of Service of bus systems on the performance of the closed-loop control and take this into account in real applications.
Content:	• Basic structure of bus systems/communication interfaces • Master/slave and Multi-master operation • Requirement on bus systems • Terminology of information theory: entropy, redundancy, decision content • Ordinary channel models, channel capacity (Shannon, Nyquist model), influence of disturbances/noise • The ISO/OSI reference model • Placement of interfaces in the ISO/OSI reference model • Physical bit transmission (NRZ/RZ signals, elementary bit coding) • Topologies (ring, star, bus...) • Arbitration process, Medium access control protocols (CSMA-CD, CSMA-CA, TDMA, Token-Ring) • Methods for securing and checking data integrity • Statistical determination of bit error rates • Basic principles of analogue and digital modulation processes

	• Network and Subnets design • VLSM Addressing • Typical bus systems in industrial automation • CANBUS • Ethernet and TCP/IP/UDP; • Advantages and disadvantages of individual systems
Assessment:	Continuous Assessment and Written examination
Forms of media:	Webex/Moodle
Literature:	1. B. Wilamowski and J. D. Irwin, Industrial Communication Systems (The Industrial Electronics Handbook), CRC Press, 2011. 2. R. Zurawski, The Industrial Communication Technology Handbook (The Industrial Information Technology Series), CRC Press, 2005. 3. Tanenbaum, Wetherall, Computer Networks, Pearson, 2014 Further Readings: 4. B. Reißenweber, Feldbussysteme zur industriellen Kommunikation, Deutscher Industrieverlag, 2009.

2323 Materials and Manufacturing of Electronics

Module name/Module Code:	Materials and Manufacturing of Electronics 2323
Degree:	Electrical and Electronics Engineering: EL 4 2323
Module coordinator:	Prof. Dr. A. Struck
Lecturer:	Prof. Dr. A .Struck, External Lecturer
Language:	English
Place in curriculum:	Core
Timetabled hours:	Materials for Electrical Engineering Lectures: 2 HPW Exercise: 1 HPW Industrial Manufacturing of Electronics Lectures: 1 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	
Module objectives:	Materials for Electrical Engineering • the structure of matter • Learning standard concepts of describing and analysing materials, especially semiconductors Manufacturing of Electronics • listing the steps of the industrial production process for electronic circuits • mastering the essential rules of drafting electronic circuits which take production capability into account • knowing troubleshooting methods and maintenance of circuits in quality control within the framework of industrial manufacturing
Content:	Materials for Electrical Engineering: • Structure of matter, Bohr model, chemical bonding • Crystals, lattices, Bravais lattice, defects • Phases of matter, phase transitions • Alloys • Phase diagrams • Application in soldering • Semiconductors, band structure, doping • Electronic structure of semiconductors, applications Manufacturing of Electronics: • Structural engineering of electronic circuits • Soldered connections • Manual soldering • Automatic soldering systems • Inspection systems and quality assurance

	• Production Management • Maintenance • 3D-MID, Flipchip technologies
Assessment:	Written examination
Forms of media:	Whiteboard, projector
Literature:	1. Rolf E. Hummel: Electronic Properties of Materials, Springer 2. Ellen Ivers-Tiffée, Waldemar von Münch: Werkstoffe der Elektrotechnik (Materials of Electrical Engineering) Further Readings: 3. N. Basak: Electrical Engineering Materials, New Age Science Ltd, 2009 4. G. Fasching, Werkstoffe für die Elektrotechnik, Springer, 2005 5. W. Sauer et al.: Electronics Process Technology: Production Modelling, Simulation and Optimisation, Springer, 2006 6. Wolf-Dieter Schmidt: Grundlagen der Leiterplatten-Baugruppen-Entwicklung und Fertigung (Fundamentals of PCB devices – Development and Manufacturing), Grin Verlag, 2009 7. Cleve Moler, Numerical Computation with Matlab, free pdf from https://de.mmathworks.com/moler/chapters.html

2324 Brain-Computer Interfaces

Module name/Module code:	Brain-Computer Interfaces 2324
Degree:	Electrical and Electronics Engineering: EL 4 2324
Module coordinator:	Prof. Dr.-Ing. I. Volosyak
Lecturer:	Prof. Dr.-Ing. I. Volosyak
Language:	English
Place in curriculum:	Focus Field Subject
Timetabled hours:	Lectures: 2 HPW Practical work: 1 HPW
Workload:	45 h attendance 50 h preparation and review 40 h exam preparation
Credits:	5
Recommended prerequisites:	
Module objectives:	The students understand the fundamentals of electrical potentials in the human brain which can be detected with non-invasive and invasive methods. They can derive, from first principles, real architectures for modern Brain-Computer Interfaces. They are able to design and build, using specialized communications structures and sensors, systems for, among other things, the support of physically handicapped individuals. They appreciate the safety and social aspects of modern Brain-Computer Interfaces and can name the relevant risks.
Content:	• Human body as electrical system • The concept of a Brain-Computer Interface • Data collection with non-invasive methods, in particular Electroencephalograms (EEG) • Fundamentals of EEG • Applications of BCIs for communication with and control of external machines • SSVEP, P300 and ERD/ERS based BCI
Assessment:	Written examination (P)
Forms of media:	Whiteboard, PowerPoint, Projector
Literature:	1. Jonathan R. Wolpaw, Elizabeth W. Wolpaw Brain-Computer Interfaces – Principles and Practice, Oxford University Press, 2012, 00/TVU33 2. Rajesh P. N. Rao Brain-Computer Interfacing, Cambridge University Press, 2013, 00/WBK78 *Further reading:* 3. Siuly Siuly, Yan Li, Yanchung Zhang EEG Signal Analysis and Classification, Springer, 2016, 00/WBK105

	4. Gerwin Schalk, Jürgen Mellinger A practical Guide to Brain-Computer Interfacing with BCI2000, Springer, 2010, 00/WBK46 5. Brendon Z. Allison, Stephen Dunne et al. Towards Practical Brain-Computer Interfaces, Springer, 2012, 00/WBK43

2325 Communication Networks

Module name / Module code:	Communication Networks 2325
Degree:	Electrical and Electronics Engineering: EL 4 2325
Module coordinator:	Prof. Dr. A. Stamm
Lecturer:	Prof. Dr. A. Stamm
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 2 HPW Exercise: 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	none
Module objectives:	It is expected that upon successful completion of the course, students will: • understand the basic theories, principles, and method of analysis of communications systems. • know the different types of operation methods and their relative advantages and disadvantages. • be able to carry out basic design and analysis calculations for some simple communication systems.
Content:	• communication networks theory • signals theory • different modulation theories (e.g. PCM) • transmission systems (e.g. wireless, wired, optical) • Baseband transmission • Fourier Transformation • Definition of Bandwidth • In-house networks • Permanent Link and Channel • Link Classes • Losses and cross talk in cables • Bit Error Rate • Synchronisation • Multiplexing • LAN & WAN • OSI • TCP/UPD • Routing • Multimedia • Security • Quality of Service
Assessment:	Written examination
Forms of media:	Webex/Moodle

Literature:	1. „Computer Networks“, 5th Edition, Andrew S. Tanenbaum, Prentice Hall PTR, 2010 2. „Computer Networking“, 4th Edition, James F. Kurose und Keith W. Ross, Addison Wesley, 2007 3. TCP/IP“, W. Richard Stevens, Hüthik, 2004

2510 Technology and Innovation Management

Module name/Module code:	Technology and Innovation Management 2510
Degree:	Electrical and Electronics Engineering: EL 7 2510 Industrial Engineering: IE 7 2510 Mechanical Engineering: ME 7 2510 Mechatronic Systems Engineering: MSE 7 2510
Module coordinator:	Prof. Dr.-Ing. D. Untiedt
Lecturer:	Prof. Dr.-Ing. D. Untiedt
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 2 HPW Practical Training: 2 HPW
Workload:	45 h attendance 75 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	-
Module objectives:	Students know the essential terms, methods and tools of technology and innovation management. They are able to arrange technologies and to evaluate these using suitable methods. They are aware of the importance of technologies for businesses and society. They know the methods and tools of technology forecasting, planning and evaluation and are able to apply these to practical problem cases. Students know the importance of innovations for businesses. They are acquainted with the relationships between innovation process, stakeholders and the internal and external business environments. They are able to apply suitable methods and instruments of innovation management in an objective-oriented manner in everyday operation. For this, a clear understanding is gained of the innovation process, its success factors and its management and controlling instruments. After completing the module, students should be able to create technology portfolios and to apply roadmaps. Furthermore they should have basic knowledge in the areas of projections and scenarios. In particular they are able to evaluate technological innovations with regard to chances and risks.
Content:	<u>Technology and Life cycle management</u> • Fundamentals of Technology management • Scope of duties of Technology management • Technology forecasting • Technology planning • Protection of intellectual property • Technology evaluation • Formulation of Technology strategies <u>Innovation management</u> • Basics concepts of Innovation management • Innovation processes and structures

	• Innovation strategies • Methods of Innovation management • Generating ideas and creativity • Open Innovation
Assessment:	Written Attestation
Forms of media:	Webex/Moodle
Literature:	Technology management 1. Schuh, G.; Klappert, S.: Technologiemanagement (Technology Management). Springer, 2010 Betz, F.: Managing Technological Innovation – Competitive Advantage from Change. 3rd edition, John Wiley & Sons, 2011 Innovation management 1. Trott, P.: Innovation Management and new product development. 4th edition. Pearson Education Ltd., 2008 Schuh, G. (Hrsg.): Innovationsmanagement. Handbuch Produktion und Management 3. Zweite, vollständig neu bearbeitete und erweiterte Auflage, Springer, 2012 Further Readings: 2. Burgelmann, R.: Strategic Management of Technology and Innovation. 5th revised edition, McGraw-Hill Higher Education, 2008 3. Arnold, H.; Erner, M.; Möckel, P.; Schläffer, Chr. (Eds.): Applied Technology and Innovation Management. Springer, 2010 4. Narayanan, V. K.; Colarelli O'Connor, G. (Eds.): Encyclopedia of Technology and Innovation Management. 1st edition, John Wiley & Sons, 2010

2512 Entrepreneurship

Module name/Module code:	Entrepreneurship 2512
Degree	Biomaterials Science: BMS 7 2512 Electrical and Electronics Engineering: EL 7 2512 Industrial Engineering: IE 7 2512 Mechanical Engineering: ME 7 2512 Mechatronic Systems Engineering: MSE 7 2512
Module coordinator:	Prof. Dr.-Ing. D. Untiedt
Lecturer:	Prof. Dr.-Ing. D. Untiedt
Language:	English
Place in curriculum:	Core
Timetabled hours:	Project: 2 HPW
Workload:	30 h attendance 20 h preparation and review 10 h exam preparation
Credits:	2
Recommended prerequisites:	2013 Business Economics and Project Management" or 2503 Internal Accounting
Module objectives:	Entrepreneurial thinking and acting of the students will be trained specifically with regard to the main responsibilities of business establishment. After finishing the module, they are able to analyse and evaluate markets, market developments, customer values and competitive advantages. They show fundamental knowledge of generating business plans in which the business concept always remains the focal point.
Content:	• Theoretical basics • Legal forms • Business plan creation
Assessment:	Attestation: Continuous Assessment
Forms of media:	Webex/Moodle
Literature:	1. Barringer, B. R.; Ireland, D.: Entrepreneurship – Successfully Launching New Ventures, 4th edition, Prentice Hall, 2012. Further Readings: 2. Lambing, P. A.; Kuehl, Ch. R.: Entrepreneurship. 4^{th} edition, Prentice Hall, 2007 3. Bygrave, W. D.; Zacharakis, A.: Entrepreneurship. Wiley, 2008

2901 Drives and Power Electronics

Module name/Module code:	Drives and Power Electronics 2901
Degree:	Electrical and Electronics Engineering: EL 3 2901 Mechatronic Systems Engineering: MSE 3 2901
Module coordinator:	Prof. Dr.-Ing. Dipl.-Wirt. Ing. R. Schmetz
Lecturer:	Prof. Dr.-Ing. Dipl.-Wirt. Ing. R. Schmetz
Language:	English
Place in curriculum:	Core
Timetabled hours:	Lecture: 2 HPW Exercise: 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	2008 Statics and Strength of Materials 2001 Introductory Mathematics 2002 Applied Mathematics 2301 Electrical Engineering I 2302 Electrical Engineering II 2304 Analog Electronics
Module objectives:	After completion of the module students are able to • perform basic analyses of drivetrains and reduce them to a single equivalent mass inertia • understand the working principles of the most common electric motors and their properties • perform simple calculations and dimensioning tasks regarding electric motors • match the properties of electric motors with the given requirements of drivetrains • describe the most common power semiconductors and their properties and application ranges • perform simple calculations regarding the losses of power semiconductors at operation • understand the fundamentals of electrical energy conversion and inversion and describe the most common energy conversion and inversion circuits • perform simple calculations on rectifiers and buck-, boost- and buckboost-converters • describe different modulation methods for converters and inverters • understand the principle of speed and torque control of electric motors fed by converters and inverters
Content:	Objectives and basics of drives and power electronics Electric motors and dimensioning of drives Power semiconductor devices and their losses Energy conversion and inversion circuits Motion control
Assessment:	Written examination

Forms of media:	Presentation, Whiteboard, Projector, Practical Demonstrations with Training-Systems
Literature:	De Doncker, R. Lecture Notes Power Electronics - Fundamentals, Topologies, Analysis, 4th edition Institut für Stromrichtertechnik und Elektrische Antriebe (ISEA), Aachen, 2013 ISBN 978-3-943496-00-0 Mohan, N., Undeland, T., Robbins, W. Power Electronics 3rd edition, John Wiley, 2003, ISBN 978-0-471-22693-2 Further Readings: Automotive Handbook, published by Robert Bosch GmbH, 8th Edition, John Wiley & Sons Ltd., Chichester, 2011 ISBN 978-1-119-97556-4 Hughes, A., Drury, B. Electric motors and drives 4th edition, Elsevier, 2013 ISBN 978-0-08-099368-3 Mott, Robert L., Tang, J. Machine Elements in Mechanical Design 4th edition in SI-units, Pearson Prentice Hall, 2004, ISBN 978-0-13-197644-3 Course materials from the lecturer Exercises from the lecturer

2902 System Theory and Controls

Module name/ Module code::	System Theory and Controls 2902
Degree:	Electrical and Electronics Engineering: EL 4 2902 Industrial Engineering: IE 4 2902 Mechanical Engineering: ME 4 2902 Mechatronic Systems Engineering: MSE 4 2902
Module coordinator:	Prof. Dr.-Ing. D. Nissing
Lecturer:	Prof. Dr.-Ing. D. Nissing
Language:	English
Place in curriculum:	Core subject
Timetabled hours:	Lectures: 2 HPW Tutorials: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 50 h preparation and review 40 h exam preparation
Credits:	5
Recommended prerequisites:	2001 Applied Mathematics 2008 Static and Strength of Materials (for EL) **or** 2010 Dynamics (for IE, ME and SE) 2301 Electrical Engineering I (for EL) **or** 2305 Fundamentals of Electrical Engineering (for IE, ME and SE)
Module objectives:	After finishing this module, students have fundamental knowledge and abilities for the mathematical description and regulation of technical systems and are able to present these via block wiring diagrams. Furthermore, students are able to analyse and evaluate mathematically described time-continuous single-input/single-output (SISO) control systems by means of system theory knowledge. By doing this, a controller can be designed correspondingly meeting given requirements regarding stationary and dynamic behaviour. Additionally, students gain the ability to deduce requirements for the necessary measurement technique. The control engineering methods learnt this way will be deepened and attested by a tutorial as well as by laboratory work. Here, computer based development tools will be used, particularly Matlab/Simulink, so students are also able to cope with descriptions, calculations and analyses in a practice-oriented manner.
Content:	• Mathematical modelling of technical systems by means of differential equations • System description via block diagrams • Functionality and basic structure of control circuits • Characteristics of control systems – Linear and non-linear systems – Linearization – Systems with concentrated/distributed parameters

	– Time-variant and time-invariant systems – Causal and non-causal systems • Description of linear continuous systems – Time domain: step response, impulse response, convolution integral – Frequency domain: Laplace transformation, transfer functions • Characteristics of systems – Proportional, integral, derivative and its combinations – Block diagram transformation – Closed-loop transfer function: Reference and disturbance transfer function • Frequency domain characteristics – Nyquist-Plot – Bode-diagram • Stability of linear continuous control systems – Definition of stability and stability condition – Hurwitz criterion/Routh criterion/Nyquist criterion – Gain and phase margin • Design method for linear continuous control systems
Assessment:	laboratory, written examination
Forms of media:	Whiteboard, PowerPoint, Projector, Computer based Engineering Tools Matlab/Simulink
Literature:	Nise, Norman S.: Control Systems Engineering. 2011, John Wiley & Sons. ISBN 978-0-470-64612-0 Dorf, R. C., R.H. Bishop: Modern Control Systems. 2011, Pearson Education. ISBN 978-0-13-138310-4 Franklin, G. F., J.D. Powell, A. Emami-Naeini: Feedback Control of Dynamic Systems. 2010, Pearson Education. ISBN 978-0-13-500150-9 Ogata, K.: Modern Control Engineering. 2010, Pearson Education. ISBN 978-0-13-713337-6

2903 Controls

Module name/Module code:	Controls 2903
Degree:	Electrical and Electronics Engineering: EL 5 2903 Mechanical Engineering: ME 5 2903 Mechatronic Systems Engineering: MSE 5 2903
Module coordinator:	Prof. Dr.-Ing. D. Nissing
Lecturer:	Prof. Dr.-Ing. D. Nissing
Language:	English
Place in curriculum:	Electrical Engineering: Focus Field Subject Mechanical Engineering: Core Mechatronic Systems Engineering: Core
Timetabled hours:	Lectures: 2 HPW Tutorials: 1 HPW Practical Training: 1 HPW
Workload:	60 h attendance 50 h preparation and review 40 h exam preparation
Credits:	5
Recommended prerequisites:	2902 System Theory and Controls
Module objectives:	After finishing the module, students are able to design, analyse, evaluate and apply enhanced controllers. For this, the knowledge gained in the module “System Theory and Controls” is used and expanded by additional processes and methods. Students will for example be able to describe control systems with multiple inputs and outputs in state space, describe time discrete systems and have the ability to develop programmable logic controllers (PLC). Furthermore, students gain the necessary skills to design and to parameterise linear observers for determining non-measurable properties or those that can only be determined by very elaborate methods. Identifying corresponding structural measures such as controllability and observability are also a part of this. Additionally, students are able to implement the controllers they have designed into digital control systems. Apart from time-discrete controllers, dimensioning and definition of control systems also fall under this aspect. The methods learned this way will be deepened and attested by tutorial as well as by laboratory work. Here, computer based development tools will be used to design a controller upon a model of the plant, particularly Matlab/Simulink and Siemens Step7, so students are also able to cope with descriptions, calculations and analyses in a practice-oriented manner.
Content:	• Programmable logic controllers (PLC) - Hardware and components - Fundamentals of logic - Flip-flops

	- PLC programming (ladder diagram, instruction list, functional block diagram, flowchart) - Karnaugh-Veitch (KV)-Diagram - Programming timers and counters • State space control - State variable representation (state space model) - Normal forms in state space representation - Stability in state space - Controllability and state space controller - Synthesis of linear control systems in state space • Reconstruction of states via observer techniques • Linear time-discrete systems (digital controlling) - Functioning of digital control systems - z-transformation - Closed-loop feedback sampled-data systems - Stability of time-discrete systems
Assessment:	Attestation within the scope of laboratory, written examination
Forms of media:	Webex/Moodle
Literature:	Nise, Norman S.: Control Systems Engineering. 2011, John Wiley & Sons. ISBN 978-0-470-64612-0 Dorf, R. C., R.H. Bishop: Modern Control Systems. 2011, Pearson Education. ISBN 978-0-13-138310-4 Petruzella, Frank D.: Programmable Logic Controllers. 2011, McGraw-Hill. ISBN 978-0-07-351088-0 Berger, Hans: Automating with SIMATIC S7-1200. 2011, Publicis. ISBN 978-3-89578-356-2

2907 Sensor and Actuator Networks

Module name/Module code:	Sensor and Actuator Networks 2907
Degree:	Electrical and Electronics Engineering: EL 5 2907 Mechatronic Systems Engineering: MSE 5 2907
Module coordinator:	Prof. Dr. A. Stamm
Lecturer:	NN External Lecturer
Language:	English
Place in curriculum:	Core: MSE Focus Field Subject: EL
Timetabled hours:	Sensors and Actuators: Practical: 2 HPW Networks: Lecture: 1 HPW Exercise: 1 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	2304 Analog Electronics 2305 Fundamentals of Electrical Engineering
Module objectives:	Students master the principles of different sensors and the further processing into data that is used in mechatronic systems. They are able to show the advantages of intelligent sensors and to judge their application. They are able to compare different effects and select suitable sensors by examples for recording different physical variables. They are able to specify the requirements for actuators in mechatronics. Students master the basic concepts of networks. They are able to classify different methods of data transmission via physical layers and distinguish the related methods of arbitration. Students are able to classify the advantages and disadvantages of different transmission methods and to select suitable bus systems for different cases of application. For this, they have knowledge of marketable bus systems for industrial applications.
Content:	Sensors and Actuators • Basic terminology and Parameters of signals • Measurement methods • Basic principles of sensors, e.g. inductive, capacitive and magnetic. • Measuring of different units, e.g. acceleration, distance etc. • Processing of sensor data • Sensor and actuator interfaces • Typical sensors in practical applications • Classification and selection of actuators • Piezo sensors and actuators

	<u>Networks</u> • Basic structure of bus systems/communication interfaces • Master/slave and Multi-master operation • Requirement on bus systems • Terminology of information theory: entropy, redundancy, decision content • Ordinary channel models, channel capacity (Shannon, Nyquist model), influence of disturbances/noise • The ISO/OSI reference model • Placement of interfaces in the ISO/OSI reference model • Physical bit transmission (NRZ/RZ signals, elementary bit coding) • Topologies (ring, star, bus...) • Arbitration process, Medium access control protocols (CSMA-CD, CSMA-CA, TDMA, Token-Ring) • Methods for securing and checking data integrity • Statistical determination of bit error rates • Basic principles of analogue and digital modulation processes • Network and Subnets design • VLSM Addressing • Typical bus systems in industrial automation • CANBUS • Ethernet and TCP/IP/UDP; • Advantages and disadvantages of individual systems
Assessment:	Written examination
Forms of media:	Webex/Moodle
Literature:	<u>Sensors and Actuators:</u> Jon Wilson, Sensor Technology Handbook, Newnes, 2004 Jacob Fraden: Handbook of modern Sensors, Springer, 2010 Jörg Haus: Optical Sensors: Basics and Applications, Wiley-VCH, 2010 <u>Networks:</u> Wilamowski Bodgan, Bodgan Wilamowski, J. David Irwin, Industrial Communication Systems (The Industrial Electronics Handbook), Crc Pr., 2011 Tanenbaum, Wetherall, Computer Networks, Pearson, 2014 Further Readings: Jon Wilson: Sensor Technology Handbook, Newnes, 2004 Robert H. Bishop: The Mechatronics Handbook - Mechatronic Systems, Sensors and Actuators, CRC Press, 2008 Sawomir Tumanski: Principles of Electrical Measurement (Series in Sensors), Inst of Physics Pub, 2006

	Gerhard Schnell, Bernhard Wiedemann, Bussysteme in der Automatisierungs- und Prozesstechnik: Grundlagen, Systeme und Trends der industriellen Kommunikation, (Bus Systems in Automation and Process Engineering: Fundamentals, Systems and Trends of Industrial Communications) Vieweg & Teubner, 2008 Friedrich Wittgruber, Digitale Schnittstellen und Bussysteme. Einführung für das technische Studium (Studium Technik) (Digital Interfaces and Bus Systems – Introduction to Engineering Studies), Vieweg, 2002 Richard Zurawski, The Industrial Communication Technology Handbook (The Industrial Information Technology Series), Crc Pr., 2005 Course materials from the lecturer