Module Handbook

for the study program

Mechatronic Systems Engineering B.Sc.

Kleve, Rev. 4 January 2023

Content

Curriculum Mechatronic Systems Engineering B.Sc

Curriculum MSE		HPW	Type						Examination form		CP	HPW						
			V	SL	S	Ü	Pra	Pro	Attestation	graded		WS1	SS2	WS3	SS4	WS5	SS6	WS7
1st Semester																		
2000	Introductory Mathematics	8	5			3				x	8	8						
2008	Statics and Strength of Materials	4	2			2				x	5	4						
2011	Programming	4	2				2		x	x	5	4						
2013	Business Economics & Project Management	4	3				1		x		5	4						
2305	Fundamentals of Electrical Engineering	4	2			1	1		x	x	5	4						
2900	Introduction to Engineering	3	2		1				x		3	3						
2nd Semester																		
2001	Applied Mathematcis	8	5			3				x	7		8					
2009	Advanced Strength of Materials	4	2			2				x	5		4					
2012	Advanced Programming	4	2				2		x	x	5		4					
2304	Analog Electronics	4	2			1	1		x	x	5		4					
2701	Engineering Drawing and Design	4	2			1	1		x	x	5		4					
2706	Manufacturing Technology	4	3			1				x	5		4					
3rd Semester																		
2010	Dynamics	4	2			2				x	5			4				
2108	Materials and Testing	4	2			1	1			x	5			4				
2306	Microcontroller	4	2				2		x	x	5			4				
2705	Engineering Design	4	2			2				x	5			4				
2708	Thermodynamics	4	2			1	1			x	5			4				
2901	Drives & Power Electronics	4	2			2				x	5			4				
4th Semester																		
2002	Numerical Mathematics	4	3			1				x	5				4			
2311	Embbeded Systems	4	2				2			x	5				4			
2902	System Theory and Controls	4	2			1	1			x	5				4			
2904	Modelling and Simulation	4	2				**2**			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			
5th Semester																		
2014	Cross-Cultural Management and Creativity	4	2			2			x		5					4		
2015	Group Project	1						1	x		5					1		
2903	Controls	4	2			1	1			x	5					4		
2907	Sensors and Actuator Networks	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		
6th Semester																		
2016	Internship / Semester abroad								x		30							
7th 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**	**27**	**28**	**24**	**24**	**21**		**9**
		HPW	**Type**						**Examination form**		**CP**	**WS1**	**SS2**	**WS3**	**SS4** **HPW**	**WS5**	**SS6**	**WS7**

Catalogue Individual Subjects MSE		HPW	Type						Examination form		CP	HPW						
			V	SL	S	Ü	Pra	Pro	Attestation	graded		WS1	SS2	WS3	SS4	WS5	SS6	WS7
Focus Fields *//***/**** **																		
	Focus Field Simulation in Mechatronics	**16**	**8**			**5**	**3**				**20**				**8**	**8**		
2710	Fluid Mechanics	4	2			1	1			x	5				4			
2908	Multibody Dynamics	4	2			2				x	5				4			
2309	Object-oriented Programming	4	2				2			x	5					4		
2905	Finite Element Method	4	2			2				x	5					4		
	Focus Field Applied Mechatronics (ME focus)	**16**	**8**			**5**	**3**				**20**				**8**	**8**		
2710	Fluid Mechanics	4	2			1	1			x	5				4			
2909	Vehicle Technology	4	2			1	1			x	5				4			
2717	Mobile Hydraulics	4	2			1	1			x	5					4		
2910	Robotics	4	2			2				x	5					4		
	Focus Field Applied Mechatronics (EL focus)	**16**	**8**			**4**	**4**				**20**				**8**	**8**		
2303	Digital Electronics	4	2			1	1		x	x	5				4			
2912	Optical Systems	4	2			1	1			x	5				4			
2308	Signal Transmission	4	2			1	1			x	5					4		
2314	Practical Electronics	4	2			**1**	**1**			x	5					4		
	Focus Field Bionics	**16**	**8**			**4**	**2**	**2**			**20**				**8**	**8**		
2723	Biomimetic Science	4	2			2				x	5				4			
2724	Zoological Physics	4	2				2			x	5				4			
2725	Bioinspiration	4	2			2				x	5					4		
2726	Bionic Design	4	2					2	x		5					4		
Electives																		
2020	Foreign Language								x		5							
2021	Module from any other Bachelor study course HSRW								x	x	5							
2911	Introduction to Scientific Methods in Mechatronics	2	1				1			x	5							2

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

** Aus dem Wahlbereich können mit dem Einverständnis des Prüfungsausschusses 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

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: Electrical and Electronics Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BMS 1 2000 EL 1 2000 IE 1 2000 ME 1 2000 MSE 1 2000
Module coordinator:	Prof. Dr. A. Kehrein	
Lecturer:	Prof. Dr. A. Struck Prof. Dr. phil. W. Megill Prof. Dr. M. Krauledat Prof. Dr. A. Kehrein Ch. Akah Neh	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise:	5 HPW 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: Electrical and Electronics Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BMS 2 2001 EL 2 2001 IE 2 2001 ME 2 2001 MSE 2 2001
Module coordinator:	Prof. Dr. A. Kehrein	
Lecturer:	Prof. Dr. A. Struck Prof. Dr. phil. W. Megill Prof. Dr. A. Kehrein Ch. Akah Neh	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise:	5 HPW 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 introduced to some mathematical concepts and methods beyond high-school level. In particular, they learn to work with infinite series, multivariate functions, and ordinary differential equations. Students learn to model situations 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. By participating actively in the exercises students practice to communicate in precise mathematical terms and 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: Mechanical Engineering: Mechatronic Systems Engineering: Biomaterials Science Electrical and Electronics Engineering	IE 4 2002 ME 4 2002 MSE 4 2002 BMS 4 2002 EL 4 2002
Module coordinator:	Prof. Dr. A. Kehrein	
Lecturer:	Prof. Dr. A. Kehrein Prof. Dr. A. Struck Ch. Akah-Neh	
Language:	English	
Place in curriculum:	Core: IE, ME, MSE Focus Field subject: BMS, EL	
Timetabled hours:	Lectures: Exercise:	3 HPW 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 roundoff 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 method, 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

2008 Statics and Strength of Materials

Module name/Module code:	Statics and Strength of Materials	2008
Degree:	Biomaterials Science: Electrical and Electronics Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BMS 3 2008 EL 1 2008 IE 1 2008 ME 1 2008 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: Exercise:	2 HPW 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

2009 Advanced Strength of materials

Module name/ Module code:	Advanced Strength of materials	2009
Degree:	Mechanical Engineering: Mechatronic Systems Engineering:	ME 2 2009 MSE 2 2009
Module coordinator:	Prof. Dr, N. H. Østergaard	
Lecturer:	Prof. Dr. N. H. Østergaard	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise:	2 HPW 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	2000 Introductory Mathematics 2008 Statics and strength of materials	
Module objectives:	The students will be on basis of the concepts of static equilibrium and internal forces be taught how to determine stresses and deformations in the most common structural elements with linear elastic constitutive behaviour.	
Content:	• Conceptual introduction to 3D statics • Introduction to the general theory of linear elasticity ▪ Cauchy's definition of stress ▪ The concept of strain ▪ Constitutive equations and Hook's law • Normal stresses and deformations in axially loaded members, truss systems • Shear stresses and twist due to torsion of compound circular shafts ▪ The polar moment of inertia • Normal and shear stress due to bending of long and slender prismatic beams ▪ The flexure formula for bending around one and two axes ▪ The second order area moment of inertia ▪ The parallel axis theorem • Deflection of long and slender beams ▪ The Bernoulli Euler beam theory ▪ Application to statically indeterminate problems and calculation of reactions • The transformation equations for states of plane stress and Mohr's circle ▪ Failure criteria (Von Mises, Tresca) • Stresses in thin-walled pressure vessels ▪ The case of a helical welding in a cylindrical pressure vessel with spherical end caps • Elastic buckling of beam-columns (Euler buckling)	

	• Introduction to matrix methods and finite element analysis
Assessment:	Written examination
Forms of media:	Whiteboard (PowerPoint, Projector, demonstration in the lecture)
Literature:	1. Primary teaching material: • Introduction to strength of materials, lecture notes and problems by NH Østergaard (will be uploaded to Moodle at the beginning of the course) 2. Recommended text book: • Mechanics of materials (Global Ed.), McGraw-Hill Beer, Johnston, DeWolf, Mazurek Recommended secondary literature: 3. Vector Mechanics for Engineers: Statics (Global Ed.), McGraw-Hill 4. Statics (SI Ed.), Wiley & Sons, Meriam & Kraige 5. Mechanics of Materials (SI Ed.),Cengage Learning, Gere

2010 Dynamics

Module name/Module Code:	Dynamics 2010
Degree:	Industrial Engineering: IE 3 2010 Mechanical Engineering: ME 3 2010 Mechatronic Systems Engineering: MSE 3 2010
Module coordinator:	Prof. Dr. N. H. Østergaard
Lecturer:	Prof. Dr. N. H. Østergaard
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:	2001 Applied Mathematics 2008 Statics and Strength of Materials
Module objectives:	The students will be taught the basic kinematics and kinetics for plane motions of particles, systems of particles and rigid bodies required for development and engineering analysis of mechanical systems. The course content will be based on Newtonian mechanics with focus on the link between kinematic properties and force. After having completed the dynamics course, students can independently formulate equations of motion and are familiar with the solution procedures.
Content:	• Particle kinematics ▪ Cartesian coordinates (recti- and curvilinear motions, rotating motion, ballistics) ▪ Polar coordinates and curvi-linear frames ▪ The concepts of relative motion and kinematic constrains • Particle dynamics, Newton's 2nd law in cartesian coordinates ▪ Free-body diagrams and kinetic diagrams ▪ mass-wire-pulley problems ▪ Coulomb friction • The linear and angular momentums and their properties ▪ Motion under a central force (for example satellites) ▪ Application to a system of particles ▪ The rocket equation (Tsiolkovsky) • Free and forced vibrations of damped and undamped single degree of freedom systems ▪ Mass-spring-damper systems ▪ The mathematical pendulum • Kinematics of rigid bodies ▪ Application of relative motion for formulation of kinematic constrains • Dynamics of rigid bodies

	▪ Euler's law of motion and moment equilibriums around arbitrary points in the plane ▪ Rolling and slipping ▪ Gears and sliding bar problems ▪ Reciprocating mechanisms • Conceptual introduction to 3D dynamics ▪ The Newton-Euler equations and gyro moments • Introduction to computational multibody dynamics
Assessment:	Written digital examination
Forms of media:	Webex/Moodle
Literature:	Primary teaching material: 1. Introduction to Dynamics, course slides and problems by NH Østergaard (will be uploaded to Moodle at the beginning of the course) Recommended text book: 2. Beer, Johnston, Cornwell: Vector Mechanics for Engineers: Dynamics (Global Ed.), McGraw-Hill Recommended secondary literature: 3. Meriam and Kraige: Dynamics (SI Ed.), Wiley Publishing,

2011 Programming

Module name/Module code:	Programming	2011
Degree:	Biomaterials Science: Electrical and Electronics Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BMS 1 2011 EL 1 2011 IE 1 2011 ME 1 2011 MSE 1 2011
Module coordinator:	Prof. Dr. M. Krauledat	
Lecturer:	Prof. Dr. M. Krauledat	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Practical Training:	2 HPW 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: Exercise:	Written examination on campus 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 Prof. Dr. A. Stamm
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 • Arrays • Input and output • Flow control • Program structures • Functions • Bitwise Operators • 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: EDX) https://www.edx.org/cs50(Accessed 09 Jan, 2023).

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:	Business Economics

	• 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: Electrical and Electronics Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BMS 1 2014 EL 3 2014 IE 2 2014 ME 2 2014 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 Creativity: Lecture & Exercise	3 HPW 1 HPW
Workload:	60 h attendance 90 h preparation and review and group assignment	
Credits:	5	
Recommended prerequisites:	none	
Module objectives:	The aim of this module is to support students to build up intercultural competencies (cognitive, affective and communicative) and acquire first basic knowledge and abilities to deal with creative processes in individual, team or organisational settings. For this, the students will • build knowledge and explore human nature in dealing with differences • reflect on the implications of various dimensions of diversity in organizational and business context. • develop an understanding of the term and nature of 'CULTURE' • self-reflect and explore the implications of dealing with change situations (e.g. culture shock) and reflect on coping strategies. • study different cultural models and learn about different dimensions of culture (e.g. Hofstede). On this basis, reflect on and develop an awareness of their own cultural background in comparison to other cultures in terms of values and behaviour. This supports students in becoming more self-reflective, mindful and adaptive when dealing with 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. • by group work, practice to use the learned creativity methods to solve engineering related challenges	

	• 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 • Dealing with change – (culture shock model) • Cultural models and dimensions of culture • Work in intercultural teams on semester assignments, preparing an term paper and presenting the results in class. Creativity: • Definition of terms like creativity, idea and innovation • 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:	Whiteboard, PowerPoint, Projector, Flip-Chart, Moderation kit
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: Electrical Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BMS 5 2015 EL 5 2015 IE 5 2015 ME 5 2015 MSE 5 2015
Module coordinator:	Heads of the degree programme	
Lecturer:	Varies depending on semester	
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:	Whiteboard, PowerPoint, Projector	
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: Electrical and Electronics Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BMS 7 2017 EL 7 2017 IE 7 2017 ME 7 2017 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

2020 Foreign language

Module name/Module code:	Foreign language	2020
Degree:	Biomaterials Science: Electrical and Electronics Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BMS 7 2020 EL 7 2020 IE 7 2020 ME 7 2020 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

2108 Materials and Testing

Module name/Module code:	Materials and Testing	2108
Degree:	Industrial Engineering: Mechatronic Systems Engineering:	IE 3 2108 MSE 3 2108
Module coordinator:	Prof. Dr. C. Heß	
Lecturer:	Prof. Dr.-Ing. R. Sicking	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise: Practical work:	2 HPW 1 HPW 1 HPW
	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:		
Module objectives:	Students are able to • describe crystal structures and different classes of metals and ceramics • explain, with basic knowledge about alloy systems, phase transformations, strength increase mechanisms as well as mechanical and technological properties of metals • identify and describe basic structures of polymers • perform different testing and analysis methods for materials characterization • describe the relationship between microstructure and macroscopic properties of polymers, ceramics, glass and metals • select appropriate materials with regard to their engineering application	
Content:	• Introduction into atomic structure and structure of single and polycrystals, lattice structures, lattice defects, alloying systems and stress-strain diagrams • Strength increase mechanisms (cold forming/plastic deformation, solid solution, grain fining, precipitates) and phase transformations • Mechanical load, fracture, corrosion • Equilibrium: component / phase / microstructure, 2-component-system / equilibrium diagrams, lever rule • Classification of polymers • Polymer states, description of polymer chain structure, chain configurations, crosslinking and branching • Structural changes by temperature, glass transition • Structure-Property relationship in polymers and metals • Microstructure and properties of ceramics and glass	

	• Introduction to important testing methods (hardness, impact test, tensile test, microscopic techniques, ultrasonic inspection, surface roughness) • Overview of main manufacturing processing routes • In addition, specific application examples are discussed
Assessment:	Lecture: Written Exam on campus Laboratory: Reports
Forms of media:	Webex/Moodle, -
Literature:	M. F. Ashby, D. R. Jones Engineering Materials 2 – An Introduction to Microstructures, Processing and Design, 3rd ed., ISBN-13 978-0-7506-6381-6, 2006 C. B. Carter, M.G. Norton Ceramic Materials – Science and Engineering, 2. ed., ISBN 978-1-4614-3522-8, Springer Verlag, 2013 Further Reading: E. Hornbogen, G. Eggeler, E. Werner Werkstoffe: Aufbau und Eigenschaften von Keramik-, Metall-, Polymer- und Verbundwerkstoffen (Materials: Structure and Features of Ceramic, Polymeric and Composite Materials), 9th completely rev. ed., ISBN 978-3540718574, Springer, 2008 M. F. Ashby, D. R. H. Jones Engineering Materials 1 - An Introduction to Properties, Applications and Design, 4th ed., ISBN 978-0-08-096665-6, Elsevier, 2012 George M. Crankovic Metals Handbook: Materials Characterization, 9th ed., ISBN 978-0871700162, ASM Intl., 1989 G. W. Ehrenstein Polymerwerkstoffe – Struktur – Eigenschaften – Anwendungen, 3. ed., ISBN 978-3-446-42283-4, Carl Hanser Verlag, 2011 E. Saldivar-Guerra, E. Vivaldo-Lima Handbook of Polymer Synthesis, Characterization and Processing, 1. ed., ISBN 978-0-470-63032-7, Wiley, 2013 Jean Louis Halary, Francoise Laupretre, and Lucien Monnerie Polymer Materials: Macroscopic Properties and Molecular Interpretations, 1. ed., ISBN 978-0470616192, Wiley & Sons., 2011

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: 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: Mechatronic Systems Engineering:	EL 2 2304 MSE 2 2304
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:	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

2305 Fundamentals of Electrical Engineering

Module name/Module code:	Fundamentals of Electrical Engineering	2305
Degree:	Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	IE 3 2305 ME 3 2305 MSE 1 2305
Module coordinator:	Prof. Dr.-Ing. G. Gehnen	
Lecturer:	Prof. Dr.-Ing. G. Gehnen	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise: Practical work:	2 HPW 1 HPW 1 HPW
Workload:	60 h attendance 50 h preparation and review 40 h exam preparation	
Credits:	5	
Recommended prerequisites:	School knowledge of Physics and Mathematics	
Module objectives:	Students are able to apply the fundamental laws of Electrical Engineering. They are able to analyze networks of passive linear components as well as to calculate currents and potentials in these networks. They are able to calculate transient processes in capacitors and inductances by means of ordinary differential equations. Additionally, they have knowledge of Alternating Currents insofar as they are able to perform simple calculations of currents, potentials and impedances with complex numbers. They are able to understand poly-phase systems. In doing so they are able to label and to estimate frequency-dependent behavior of a circuit. They know the dangers originating from electric current. The learned abilities are trained in the exercise and attested in accompanying tutorials and in the laboratory.	
Content:	• General introduction to Electrical Engineering, historical backgrounds • Electrostatics: atoms, electrons and charge • Coulomb‘s law • Current as charge movement • Electric potential and voltage • Resistors, Ohm’s law • Electric safety • Series and parallel circuit of resistors	

	• Kirchhoff's laws • Mesh Analysis • Electric power and energy • Superposition principle • Thevenin's theorem, alternative sources • Fundamentals of capacitors • Transient processes at capacitors • Induction law • Inductivities and their relation to capacitors • Transient processes at inductivities • Fundamentals of alternating currents engineering • Calculating with complex numbers in alternating currents engineering, basics of phasor diagrams • Root mean squares and peak values • Calculation of impedance and admittance • Networks in complex notation, application of phasor diagrams • Energy and power in alternating current networks • Polyphase systems • Frequency-dependent behaviour
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 2. T.L. Floyd D.M. Buchla, Electronics Fundamentals, 8th Edition, Person, 2010 3. G. Hagmann: Grundlagen der Elektrotechnik, 15. Auflage, AULA Verlag, 2011 4. G. Hagmann: Aufgabensammlung zu den Grundlagen der Elektrotechnik, 14. Auflage, AULA Verlag, 2010 5. Course materials from the lecturer 6. Laboratory documents and Exercises from the lecturer

2306 Microcontrollers

Module name/Module Code:	Microcontrollers	2306
Degree:	Electrical and Electronics Engineering: Mechatronic Systems Engineering:	EL 3 2306 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: Practical Training:	2 HPW 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

2308 Signal Transmission

Module name/Module code:	Signal Transmission	2308
Degree:	Electrical and Electronics Engineering: Mechatronic Systems Engineering:	EL 3 2308 MSE 5 2308
Module coordinator:	Prof. Dr. A. Stamm	
Lecturer:	Prof. Dr. A. Kehrein F. Kremer	
Language:	English	
Place in curriculum:	Core (EL), Focus Field Subject (MSE)	
Timetabled hours:	Lecture: Exercise: Practical Training:	2 HPW 1 HPW 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: Mechatronic Systems Engineering:	EL 3 2309 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: Practical Training:	2 HPW 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.

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:	Continuous 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.

2314 Practical Electronics

Module name / Module code:	Practical Electronics	2314
Degree:	Electrical and Electronics Engineering: Mechatronic Systems Engineering:	EL 5 2314 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: Exercise: Practical Training:	2 HPW 1HPW 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

2510 Technology and Innovation Management

Module name/Module code:	Technology and Innovation Management	2510
Degree:	Electrical and Electronics Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	EL 7 2510 IE 7 2510 ME 7 2510 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: Practical Training:	2 HPW 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:	Technology and Life cycle management • Fundamentals of Technology management • Scope of duties of Technology management • Technology forecasting • Technology planning • Protection of intellectual property • Technology evaluation • Formulation of Technology strategies Innovation management • 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: Electrical and Electronics Engineering: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	BMS 7 2512 EL 7 2512 IE 7 2512 ME 7 2512 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. 4th edition, Prentice Hall, 2007 3. Bygrave, W. D.; Zacharakis, A.: Entrepreneurship. Wiley, 2008	

2701 Engineering Drawing and Design

Module name/Module code:	Engineering Drawing and Design	2701
Degree:	Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	IE 2 2701 ME 2 2701 MSE 2 2701
Module coordinator:	Prof. Dr.-Ing. S. Danjou	
Lecturer:	Prof. Dr.-Ing. S. Danjou	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise: Practical Training:	2 HPW 1 HPW 1 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Prerequisites:	none	
Module objectives:	On successful completion of the module, students are able to use a Computer Aided Design (CAD) package to create and develop design ideas through 3D modelling and 2D drawings. Furthermore, the students know the organizational structure as well as the form and content of a development process and understand the role of CAD in the engineering design process. They are able to create and read technical drawings for various projection methods. They are able to apply CAD techniques to address design briefs and to independently produce appropriate part documentation, focusing on single part design and their manufacturing drawings. Students are able to define necessary views and sections, and prepare drawings for an intended purpose. Students prove their learning progress with independently produced 3D models and technical drawings with the help of the CAD package SolidWorks. They learn to use book of tables and engineer guidelines to ensure the drawings comply with international standards. They understand the need for a structured approach in the design process and define requirements for product development and utilization of the product.	
Content:	• General introduction to Product Development • Design methodology acc. VDI 2221 • Introduction to 3D CAD modelling • Importance of technical drawings • Standardization: DIN, EN, ISO • Layout and lettering	

	• Application of lines, line groups and line widths • Types of projection • Sectional and auxiliary views • Application-oriented dimensioning • Dimensional tolerancing • ISO system of fits: shaft-based / hole-based • Geometric tolerancing • Definition of surface properties (surface textures) • Drawing types such as working drawings, assembly drawings, variant drawings • Parts lists: types and representation • Graphic representation of standardized fastening devices (threads, bolts, screws, washers, circlips, keys) • Representation of common machine elements (roller bearings, springs, pins) •
Assessment:	Attestation within the scope of laboratory and written examination (graded)
Forms of media:	Whiteboard, PowerPoint, projector, demonstration in the lecture, practical training
Literature:	Colin H. Simmons, Dennis E Maguire, Neil Phelps: Manual of Engineering Drawing – Technical Product Specification and Documentation to British and International Standards, 3rd edition, Elsevier/Newnes, 2006 Cecil Jensen, Jay D. Helsel, Dennis R. Short: Engineering Drawing & Design, 7th revised edition, McGraw-Hill Higher Education, 2007 U. Fischer: Mechanical and Metal Trades Handbook, 3rd Edition, Europa-Lehrmittel, 2013 G. Pahl, W. Beitz, J. Feldhusen, K.H. Grote: Engineering Design – A Systematic Approach, 3rd ed. 2007 (4. November 2014), Springer, 2014 Further reading: Gary R. Bertoline: Fundamentals of Graphics Communication, 6th ed., McGraw-Hill, 2010 Hans Hoischen, Andreas Fritz: Technisches Zeichnen – Grundlagen, Normen, Beispiele, Darstellende Geometrie (*Technical Drawing – Fundamentals, standards, examples, descriptive geometry*), 35th revised and updated edition, Cornelsen-Verlag, 2016 Course materials from the lecturer Exercises from the lecturer

2705 Engineering Design

Module name/Module code:	Engineering Design	2705
Degree:	Industrial Engineering: Mechatronic Systems Engineering:	IE 5 2705 MSE 3 2705
Module coordinator:	Prof. Dr.-Ing. P. Kisters	
Lecturer:	K. Schacky	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise:	2 HPW 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Prerequisites:	2701 Engineering Drawing and Design	
Module objectives:	After successfully finishing the module, students are able to transfer physical principles to the calculations of components. They recognise fluxes and disturbances of those and present constructive improvement measures. Students know essential design rules and apply them to the designing of components. They conduct design calculations of simple machine elements and are finally able to select and design them under consideration of the aspects of reliability, material use and cost. They are able to calculate potentials relating to component strains and to evaluate them compared to given component key figures.	
Content:	• Introduction to strength calculation of real components • Material characteristics, elastic and plastic deformation, yield strength, fracture strength • Equivalent stress concepts and theories for calculation of machine elements • Definition of limit and long life fatigue strength, influence of stress cycles on component lifespan • Influence of design on component strains, notch effects and frame influence • Dimensioning and calculation of elastic springs under torsional stressing • Design of springs and spring systems • Systematic arrangement of component joints • Dimensioning and designing of bolt joints • Dimensioning and designing of compression joints with divided and slotted hub • Theoretical fundamentals of threads, selection and application limits of screwed joints • Designing and calculating of screwed joints under consideration of different load conditions	

	• Welding techniques and applications as well as weldability • Representation of various verification concepts • Design, calculation and structural limits of welding joints • Design of roller bearings • Roller bearing calculation under consideration of operating conditions (temperature, lubrication) and combined axial/radial strain
Assessment:	Written examination
Forms of media:	Webex/Moodle
Literature:	Richard G. Budynas: Shigley's Mechanical Engineering Design, Student international edition, 10th revised edition, ISBN 978-9814595285, McGraw-Hill College, 2009 Robert L. Mott: Machine Elements in Mechanical Design, 4th edition, ISBN 978-0130618856, Prentice Hall, 2003 Course materials from the lecturer Exercises from the lecturer Further Reading: Roloff/Matek: Maschinenelemente: Normung, Berechnung, Gestaltung (Machine Elements: Standardization, Calculation, Design), 22nd revised and expanded edition, ISBN 978-3658090814, Vieweg Teubner, 2011) Decker: Maschinenelemente: Funktion, Gestaltung und Berechnung (Machine Elements: Function, Design and Calculation), 19th updated edition, ISBN 978-3446438569, Carl Hanser Verlag, 2011

2706 Manufacturing Technology

Module name/ Module code::	Manufacturing Technology	2706
Degree:	Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	IE 2 2706 ME 4 2706 MSE 2 2706
Module coordinator:	Prof. Dr.-Ing. A. Klein	
Lecturer:	Prof. Dr.-Ing. A. Klein	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise:	3 HPW 1 HPW
Workload:	60 h attendance 45 h preparation and review (3 h per week) 45 h exam preparation	
Credits:	5	
Recommended prerequisites:	none	
Module objectives:	Students have a good overview about many manufacturing technologies and know the basic advantages and disadvantages of the technologies. They know the most important process parameters of most technologies and have an understanding of the challenge to find good process parameters to achieve a good total utility of the process with oftentimes-conflicting goals. Furthermore, they have a good basic knowledge about the types of machines used for the manufacturing technologies. They understand the quality requirements of machine tools and other related pieces of production equipment and metrology equipment needed for quality assurance. Additionally, they know the basic functions of CAM tools (computer aided manufacturing) and its role in industrial manufacturing (and the CAD/CAM chain).	
Content:	Manufacturing technologies (structure similar to DIN 8580) • Definition of value creation and disambiguation against other forms of production (such as chemical processing, agricultural production (farming etc.), assembly, food and beverage production) • Primary forming (casting (sand casting, injection moulding etc.), powder pressing (with subsequent sintering), additive manufacturing (stereo lithography, SLM (selective laser melting) and SLS (selective laser sintering), FDM/FFF (fused deposition modelling/ fused filament fabrication)), three dimensional printing)) • Deforming (cold deforming, warm deforming, sheet metal forming, bulk deforming, true strain, strain hardening, tool and die making and repair) • Disaggregation (turning, milling (including gear hobbing and 5 axis milling), drilling, broaching, tapping, sawing, grinding, honing, lapping, cutting tool materials, cutting	

	tool wear, cutting tool coatings, dry and wet cutting, burr creation and deburring, unwanted collateral effects (e.g. grinding burn and white layers), process disturbances (e.g. chatter (basics only)) EDM (electrical discharge machining), ECM (electro chemical machining)) • Joining (welding, soldering, glueing) (basics only, redundancy to metallic materials to be avoided) • Coating (PVD, CVD, electro plating) (basics only) • Change of material properties (heat treatment processes and heat distortions as collateral effects) (basics only) Manufacturing equipment and software (basics only): • Machine tool types • Important properties and quality characteristics of machine tools • Important components in machine tools • CNC technology • Related equipment: tools, workholding (clamping systems), metrology equipment, CAM systems Quality assurance (not quality management): • Destructive and non-destructive testing • Sample testing and 100% testing • First part qualification • Batch effects • Metrology equipment (basics only) Eventually: • Job profiles for people with manufacturing expertise • Basics of technology development (and purpose of DoE (design of experiments))
Assessment:	Written examination
Forms of media:	projector, Power point with notes (electronic pen in ppt slides during lecture), whiteboard
Literature:	Kalpakjian & Schmid: Manufacturing Processes for Engineering Materials, 5th edition, ISBN 978-0132272711, Prentice Hall Lecture slides provided to students Further reading / self-study material: • virtual laboratory (videos, HSRW own production) • youtube videos of many manufacturing technologies • Further readings in public domain (e.g. open courseware or wikipedia articles on selected topics) • Question catalogue for exam preparation

2708 Thermodynamics

Module name/Module code:	Thermodynamics	2708
Degree:	Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	IE 5 2708 ME 3 2708 MSE 3 2708
Module coordinator:	Prof. Dr.-Ing. K. Masuch	
Lecturer:	Prof. Dr.-Ing. K. Masuch	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lectures: Exercise: Practical Training:	2 HPW 1 HPW 1 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	2000 Introductory Mathematics 2003 Physics	
Module objectives:	Students know the terminology of intensive and extensive state variables (temperature, pressure, specific volume) and are able to apply them correspondingly. They are able to apply the first and second law of thermodynamics for closed and open system. They are able to solve thermodynamic problems by applying enthalpy and entropy correctly. They are able to analyse thermodynamic cycles, i.e. Carnot cycle, Rankine cycle, Stirling cycle, Otto cycle and Diesel cycle. With this knowledge, students are able to analyse gas and vapour power systems such as a steam power plant or a gas turbines and to determine their thermal efficiencies. In the laboratory framework, students learn how to measure temperature and pressure, how a boiling curve can be determined with a Marcet boiler, and how an ideal gas behaves under different conditions. They learn how to operate a steam engine, a hot-air engines, i.e. a Stirling motor, and an air compressor especially with regard to valid safety standards.	
Content:	Based on a detailed elaboration of the fundamentals of thermodynamics, the first and second law of thermo-dynamics will be introduced. This offers the requisite knowledge to be able to deal with thermodynamic processes like vapour and gas power systems. In detail, the module contains the following: 1 General fundamentals 1.1 System and control volume 1.2 State and state variables 1.3 Process and change of state 1.4 Evaluating properties	

	2 First law of thermodynamics 2.1 Work and heat 2.2 Inner energy and enthalpy 2.3 Conservation of energy for a control volume 2.4 First law for steady-state flow processes 3 Second law of thermodynamics 3.1 Clausius statement and Kelvin statement 3.2 Definition of entropy 3.3 Reversible and irreversible processes 3 Gas power systems 3.1 Carnot cycle 3.2 Otto cycle 3.3 Diesel cycle 4 Vapour power systems 4.1 Rankine cycle with superheating and reheating 4.2 Gas and steam turbine power plants (‘GuD’)
Assessment:	Graded written examination
Forms of media:	Moodle
Literature:	Michael J. Moran, Howard Shapiro: Fundamentals of Engineering Thermodynamics, SI-Version, ISBN 978-0-470-54019-0 Further Readings: Robert Balmer: Modern Engineering Thermodynamics, ISBN 978-0-12-374996-3 Yunus A. Cengel, Michael A. Boles: Thermodynamics An Engineering Approach: 7thedition in SI-Units, ISBN 978-007-131111-3 Claus Borgnakke, Robert E. Sonntag: Fundamentals of Thermodynamics, International Student Version, 7thedition, ISBN 978-0-470-17157-8

2710 Fluid Mechanics

Module name/Module code:	Fluid Mechanics 2710
Degree:	Mechanical Engineering: ME 4 2710 Industrial Engineering: IE 4 2710 Mechatronic Systems Engineering: MSE 4 2710
Module coordinator:	Prof. Dr.-Ing. K.Masuch
Lecturer:	Prof. Dr.-Ing. J. Gebel (External Lecturer)
Language:	English
Place in curriculum:	Focus Field Subject
Timetabled hours:	Lectures: 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:	
Module objectives:	On completion of this module the student is able to... – understand the principles of Fluid Mechanics, – identify the importance and role of Fluid Mechanics within the Mechanical Engineering profession, – understand how physical principles such as conservation of mass, momentum, and energy determine fluid behaviour and lead to mathematical descriptions of key features; – understand the advantages and limitations of Fluid Mechanics models, equations and formulae; – use the principles of Fluid Mechanics to solve engineering problems involving such quantities as velocity, pressure, forces (e.g. friction, drag, lift), power requirements, and efficiency. In the laboratory framework, students learn how to measure the pressure losses of a piping system, how to operate a Venturi meter to determine the flow velocity in a tube, how to determine the velocity of fall using Stokes' law, and how to operate a sedimentation basin.
Content:	• Fluid Properties – Density, viscosity, compressibility • Fluids at rest (Hydrostatics) – Pressure in liquids at rest – Stability of submerged and floating objects – Rotating containers • Fluids in motion – Pathlines, streaklines and streamlines – Viscous and inviscid flows – Laminar and turbulent flows • Integral forms of the fundamental laws – Equation of continuity

	– Energy equation – Bernoulli equation – Momentum equation • Internal flows – Laminar and turbulent flow between plates – Laminar and turbulent flow in a pipe – Hagen-Poiseuille equation • External flows – Flow around immersed bodies – Stokes law – Lift and drag on airfoils • Introduction to Computational Fluid Dynamics CFD
Assessment:	Graded written examination
Forms of media:	Smartboard/WACOM-Board, PowerPoint, Projector
Literature:	Merle C. Potter, David C. Wiggert, Bassem H. Ramadan: Mechanics of fluids. 4th edition, ISBN 978-1-4390-6203-6 Further Readings: K.S.N. Raju: Fluid Mechanics, Heat Transfer, and Mass Transfer. Chemical Engineering Practice. John Wiley & Sons, 2011. ISBN 978-0-470-63774-6 Pijush K. Kundu, Ira M. Cohen. Fluid Mechanics. Elsevier, 2008. Fourth Edition, ISBN 978-0-12-381-399-2 Herbert Oertel jr., Sebastian Ruck. Bioströmungsmechanik. Vieweg+Teubner Verlag, 2012. 2. Auflage, ISBN 978-3-8348-1765-5.

2717 Mobile Hydraulics

Module name/Module code:	Mobile Hydraulics 2717
Degree:	Mechanical Engineering: ME 5 2717 Mechatronic Systems Engineering: MSE 5 2717
Module coordinator:	Prof. Dr.-Ing. Dipl.-Wirt. Ing. R. Schmetz
Lecturer:	Prof. Dr.-Ing. Dipl.-Wirt. Ing. R. Schmetz
Language:	English
Place in curriculum:	Focus Field Subject
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:	2010 Dynamics 2305 Fundamentals of Electrical Engineering 2711 Drive Systems or 2901 Drives and Power Electronics
Module objectives:	After completion of the module students are able to • understand the principles of industrial and mobile hydraulic systems and compare them with mechanical, pneumatic, mechatronic and electric drives • read and understand hydraulic circuit diagrams • explain the differences between industrial and mobile hydraulic applications • describe typical applications of mobile hydraulics and explain their advantages and disadvantages • assign the functions to typical mobile hydraulic components, arrange them in mobile hydraulic circuits and conduct simple calculations • use electric actuators and analog closed control loops in industrial and mobile hydraulic applications
Content:	Fundamentals of hydraulics, typical applications, advantages and disadvantages, definitions and contexts Industrial and mobile hydraulic components: Fluids, pumps, cylinders, motors, valves, orifices, accumulators, filters, containers and sensors Industrial Hydraulics Mobile hydraulic throttle control systems Mobile hydraulic load sensing systems Mobile hydraulic load pressure independent flow distribution (LUDV) systems

	Analog closed control loops
Assessment:	Written examination
Forms of media:	Presentation, Whiteboard, Projector, Practical Demonstrations with Trainings System
Literature:	Course materials from the lecturer Exercises from the lecturer Further Readings: Project-Manual “Industrial Hydraulics” Publisher: Bosch-Rexroth AG, 2007, Order No. R961003751 Project-Manual “Mobile Hydraulics - Throttle Control” Publisher: Bosch-Rexroth AG, 2011, Order No. R961005093 Project-Manual “Mobile Hydraulics - Load Sensing Control” Publisher: Bosch-Rexroth AG, 2011, Order No. R961005146 Project-Manual “Mobile Hydraulics - LUDV” Publisher: Bosch-Rexroth AG, 2011, Order No. R961005148 Project-Manual “Analog Position Control Loop” Publisher: Bosch-Rexroth AG, 2011, Order No. R961005092

2723 Biomimetic Science

Module name/Module code:	Biomimetic Science 2723
Degree:	Mechanical Engineering ME 4 2723 Mechatronic Systems Engineering MSE 4 2723
Module coordinator:	Prof. Dr. W. Megill
Lecturer:	Prof. Dr. L. Chambers
Language:	English
Place in curriculum:	Focus Field Subject
Timetabled hours:	Lecture: 2 HPW Exercises: 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation
Credits:	5
Recommended prerequisites:	none
Module objectives:	Upon completion of this module, students will have an understanding of the developing theory which underlies the field of biomimetics and will appreciate the clear and subtle differences between conventional and biomimetic engineering design.
Content:	• Review of engineering design • Introduction to biomimetics • Terminology: biomimetics, bionics, bioinspiration • VDI design approach • Contrasts between conventional and biomimetic approaches to design • TRIZ and BioTRIZ • Ontology • Adaptation and iterative prototyping • Convergent evolution and bioinspiration • Lightweight structures (Leichtbau) • Self-healing materials and design • Sensors, feedback, control and smart materials • Oscillation, resonance, and efficiency
Assessment:	Final written exam
Forms of media:	Whiteboard, PowerPoint, Projector, Flip-Chart, Moderation kit, Films
Literature:	Vincent JFV, et al. Proc Roy Soc.: Course notes

2724 Zoological Physics

Module name/Module code:	Zoological Physics 2724
Degree:	Mechanical Engineering, Mechatronic Systems Engineering ME 4 2724 SE 4 2724
Module coordinator:	Prof. Dr. W. Megill
Lecturer:	Prof. Dr. W. Megill
Language:	English
Place in curriculum:	Focus Field Subject
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:	2000 Introductory Mathematics 2001 Applied Mathematics 2003 Physics
Module objectives:	At the completion of this module, students will have learned to apply the principles of classical physics to explain the function of animal systems.
Content:	• Animal thermodynamics • Physics of standing up - statics • Locomotion in air and water • Locomotion on land • Animals in non-inertial frames • Predator-prey interactions • Scaling in the natural world • Physics of mechanosensing • Optics in zoology • Bioacoustics • Echolocation • Electrical and magnetic senses • Nerves and information processing
Assessment:	Continuous Assessment
Forms of media:	Board and projector, video, online research
Literature:	Core text: Ahlborn B-K. (2006): Zoological Physics: Quantitative Models of Body Design, Actions, and Physical Limitations of Animals

2725 Bioinspiration

Module name/Module code:	Bioinspiration	2725
Degree:	Mechanical Engineering Mechatronic Systems Engineering	ME 5 2725 MSE 5 2725
Module coordinator:	Prof. Dr. W. Megill	
Lecturer:	Prof. Dr. L. Chambers	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lecture: Exercise:	2 HPW 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	none	
Module objectives:	Upon successful completion of this module, the students will have a familiarity with the main themes and facts of natural history (biology, evolution and ecology) as they apply to bioinspiration and bionic engineering.	
Content:	• Introduction to natural history • Role of natural history in bionic inspiration • Concepts of niche & species • Evolution & adaptation • Genes, demes, and heredity • Describing & measuring biodiversity • Biogeography & its rules • Organising Natural History knowledge • Inspiration from knowledge • TRIZ & BioTRIZ: building the databases • Applying inspiration: making it work • Bioinspiration and the engineering design process	
Assessment:	Final written exam	
Forms of media:	Webex/Moodle	
Literature:	Core text: A. Mukherjee (2010): Biomimetics Learning from Nature, InTech	

2726 Bionic Design

Module name/Module code:	Bionic Design	2726
Degree:	Mechanical Engineering Mechatronic Systems Engineering	ME 5 2726 MSE 5 2726
Module coordinator:	Prof. Dr. W. Megill	
Lecturer:	Prof. Dr. L. Chambers Prof. Dr. W. Megill	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lecture: Project:	2 HPW 2 HPW
Workload:	30 h attendance 30 h preparation and review 60 h project work and write up 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	none	
Module objectives:	Upon completion of this module, students will have learned to apply biomimetic design tools to the solution of practical technical problems.	
Content:	• Biomimetic design process • Embracing large deformations and resonance • Iterative prototyping in practice • Curves and soft materials in CAD • Genetic algorithms • Materials in biomimetics • Manufacturing biomimetic design • 3D printing, cryo-machining • Case studies of conventional and engineering design • Biomimetic design project	
Assessment:	Attestation, Project report	
Forms of media:	Webex/Moodle	
Literature:	Course notes	

2900 Introduction to Engineering

Module name/Module code:	Introduction to Engineering 2900
Degree:	Mechatronic Systems Engineering: MSE 1 2900
Module coordinator:	Heads of the degree program
Lecturer:	Prof. Dr.-Ing. T. Brandt Prof. Dr.-Ing. H. Schütte Prof. Dr. A. Struck 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 Introduction to Mechatronic Systems Engineering: Lecture: 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 Introduction to Engineering 15 h attendance 15 h preparation
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 oganizations.

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
Assessment:	Attestation
Forms of media:	Webex/Moodle
Literature:	Reporting and Descriptive Statistics: Devore, J. (2012). *Probability and Statistics for Engineering and the Sciences* (8th edition Ausg.). Boston: Brooks/Cole. Mittal, H. V. (2011). *R Graphs Cookbook.* Brimingham - Mumbai: Packt Publishing Basics of Communication and Self-Management: Different literature related to the different topics as well as additional learning material will be provided during class.

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: Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	EL 4 2902 IE 4 2902 ME 4 2902 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: Tutorials: Practical Training:	2 HPW 1 HPW 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:	written examination
Forms of media:	Whiteboard, PowerPoint, Projector, Computer based Engineering Tools Matlab/Simulink, Laboratory
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: Mechanical Engineering: Mechatronic Systems Engineering:	EL 5 2903 ME 5 2903 MSE 5 2903
Module coordinator:	Prof. Dr.-Ing. D. Nissing	
Lecturer:	Prof. Dr.-Ing. D. Nissing	
Language:	English	
Place in curriculum:	Electrical Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	Focus Field Subject Core Core
Timetabled hours:	Lectures: Tutorials: Practical Training:	2 HPW 1 HPW 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

2904 Modelling and Simulation

Module name/Module code:	Modelling and Simulation	2904
Degree:	Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	IE 5 2904 ME 5 2904 MSE 4 2904
Module coordinator:	Prof. Dr.-Ing. T. Brandt	
Lecturer:	Prof. Dr.-Ing. T. Brandt	
Language:	English	
Place in curriculum:	Industrial Engineering: Mechanical Engineering: Mechatronic Systems Engineering:	Focus Field subject Core subject Core subject
Timetabled hours:	Lectures: Practical Training:	2 HPW 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	2010 Dynamics	
Module objectives:	After successfully finishing the module, students are able to apply engineering modelling techniques to problems arising in the fields of mechanical and electrical engineering. Besides mechanical or electrical systems this includes also examples like DC-motors that link different technical domains together. The students should be able to select suitable simulation methods for technical systems and to apply them practically e.g. in MATLAB/Simulink. The students are able to identify steady states of dynamic systems and are able to linearize about them in order to create linear state space models. The student is familiar with basic numerical solution methods for differential equations. Finally, students should be able to interpret simulation results correctly and should be able to estimate the reliability of simulation results after completing the module.	
Content:	The course covers the fundamental methods of Modelling and Simulation of engineering systems (lecture) and applications (exercise) Contents in detail: • Definitions, general concepts • Methods of modelling of engineering systems • Introduction of differential and shortly to differential-algebraic equations • Identification of steady states • Linearization • Constraints of technical systems • Numerical methods for solving linear and non-linear state equations (initial value problems)	

	• Identification of parameters • Application of MATLAB/Simulink
Assessment:	Examination (oral or written)
Forms of media:	Webex/Moodle
Literature:	Klaus Janschek: Mechatronic Systems Design: Methods, Models, Concepts, Springer 2012, SBN-13: 978-3642175305 Further Readings: F.E. Cellier: Continuous System Modeling, Springer Verlag, 1991

2905 Finite Element Analysis

Module name/Module code:	Finite Element Analysis	2905
Degree:	Mechanical Engineering: Mechatronic Systems Engineering:	ME 5 2905 MSE 5 2905
Module coordinator:	Prof. Dr.-Ing. H. Schütte	
Lecturer:	Prof. Dr.-Ing. H. Schütte	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lecture: Exercise:	2 HPW 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	2002 Numerical Mathematics 2106 Metallic Materials and Testing or 2108 Materials and Testing	
Module objectives:	The students are able to decide when and if it is advisable to use the Finite Element Method as the proper numerical tool. They know the theoretical background of the method and are able to build up FEM simulation models. They are able to introduce engineering modelling simplifications to balance effort and accuracy. Using their mechanical and physical background knowledge they can define material properties, boundary conditions and interpret solution results. They can evaluate the proper quality of an FEM discretization (mesh). They know how to approach geometrically and material non-linearities of the models. They interpret results with respect to their accuracy and if these are suitable for the design purpose of the simulation. The students are able to undertake their own analysis and write the corresponding reports and can discuss the results based on presentations.	

Content:	Idea of FEM Impact on and position of FEM in the engineering design process • Comparison of advantages and disadvantages of analytical, numerical and especially FEM solutions • Different element types and shape functions • Element and mesh quality • Material models, especially Plasticity • Differences between linear and non-linear models • Examples of non-linear simulations • Simulating contact • Writing reports on calculations and present them • Critical analysis of simulation results • Limitations of FEM Calculations • Design and Optimization of Parts using elastic and elasto-plastic material models
Assessment:	written examination (homework assignment)
Forms of media:	Webex/Moodle
Literature:	H. Lee: Finite Element Simulations With ANSYS Workbench 16, ISBN 978-1585039838 SDC Publication, 2016 Erdogan Madenci, Ibrahim Guven: The Finite Element Method and Applications in Engineering Using ANSYS, Corrected and 4th printing, ISBN 978-0-387-28289-3, Springer, 2007

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:	Prof.-Ing. Ch. Budelmann
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 Networks

	• 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:	Sensors and Actuators: 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 Networks: 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

2908 Multibody Dynamics

Module name/Module Code:	Multibody Dynamics	2908
Degree:	Mechanical Engineering: Mechatronic Systems Engineering:	ME 4 2908 MSE 4 2908
Module coordinator:	Prof. Dr.-Ing. T. Brandt	
Lecturer:	Prof. Dr.-Ing. T. Brandt	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lectures: Exercises:	2 HPW 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	2002 Numerical Mathematics 2010 Dynamics 2011 Programming	
Module objectives:	After successfully finishing the module, students are familiar with the fundamentals of multibody dynamics. They are able to apply basic concepts from linear algebra such as vectors and matrices to mechanical systems. The kinematics of technical joints such as revolute joints can be modelled by algebraic constraints by the student. The student is also able to model the dynamics of constraint multibody dynamic systems based on the method of Newton-Euler. Furthermore, the student is able to develop basic programming code in order to simulate planar multibody dynamic systems and to perform analysis of planar multibody dynamic systems.	
Content:	The course focuses on the modelling and numerical simulation of dynamic multibody systems. Main subjects are: • Definitions: bodies, joints, and coordinates • Planar kinematics: rotation, translation • Kinematic constraints • Dynamics: Newton-Euler equations • Development of multibody dynamics simulation code • Analysis of multibody dynamic systems	
Assessment:	Examination (oral or written)	
Forms of media:	Whiteboard, PowerPoint, Projector, in PC exercises: MATLAB/Simulink	
Literature:	P. E. Nikravesh: Planar Multibody Dynamics - Formulation, Programming, and Application, CRC press,2008	

	Further Readings: A.A. Shabana: Dynamics of Multibody Systems, 1998

2909 Vehicle Technology

Module name/Module code:	Vehicle Technology	2909
Degree:	Mechatronic Systems Engineering:	MSE 4 2909
Module coordinator:	Prof. Dr.-Ing. D. Nissing	
Lecturer:	Prof. Dr.-Ing. D. Nissing	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lectures: Exercise: Practical Training:	2 HPW 1 HPW 1 HPW
Workload:	45 h attendance 65 h preparation and review 40 h exam preparation	
Credits:	5	
Recommended prerequisites:	2010 Dynamics 2902 System Theory and Controls 2904 Modelling and Simulation	
Module objectives:	After completing this elective subject, students have knowledge of essential systems and components in vehicles. They are able to describe mathematically the characteristics of components and are able to integrate and analyse these in the overall context for the corresponding tasks of distinguishing features and typical characteristics for vehicles. The knowledge and methods from the modules “System Theory and Controls”, “Dynamics” and “Modelling and Simulation” will be applied to vehicle technology. After completing this course, students have gained the ability to describe vehicle dynamics in all six coordinates (longitudinal, lateral, vertical, pitch, roll and yaw behavior) and have the knowledge as to which components and systems characterise the respective behaviour and how to influence the dynamic behaviour, such as over and under-steering by ESP. The gained knowledge will be deepened by practical tutorials. Here, computer based development tools are used, especially Matlab/Simulink, so students are also able to describe, calculate and analyse the different systems and features in a practical way.	
Content:	• Overview – Terminology – Control loop driver – vehicle – environment – Active and passive safety – Coordinate systems • Requirements of driving dynamics of vehicles • Suspension kinematics • Chassis systems and components (tire, axles and suspensions, spring-damper elements)	

	• Vertical dynamics • Longitudinal dynamics – Driving resistances – Braking • Lateral dynamics – Steering kinematics – Single-track (bicycle) model – Self-steering: over/under-steering – Multi-track model • Vehicle control systems – ABS/ESP – Semi-active damper – Overlay of steering moments, steering angles – Active suspensions • Driver assist functions
Assessment:	90 % Examination (oral or written) 10 % Pitch Presentation during the semester
Forms of media:	Whiteboard, PowerPoint, Projector, Computer based Engineering Tools MATLAB/Simulink, Guest lecturer from the industry (if possible)
Literature:	George Rill: Road Vehicle Dynamics. CRC Press. 2012. ISBN 978-1-4398-3898-3. Bernd Heißing, Metin Ersoy: Chassis Handbook. Vieweg. 2011. ISBN 978-3-8348-0994-0. Further reading: Giancarlo Genta: Motor Vehicle Dynamics. World Scientific. 2008. ISBN 978-981-02-2911-5. Reza N. Jazar: Vehicle Dynamics. Springer. 2008. ISBN 978-0-387-74243-4. H.-H. Braess, U. Seiffert: Vieweg Handbuch der Kraftfahrzeugtechnik (Handbook of Motor Vehicle Engineering). Vieweg. 2007. ISBN 978-3-8348-0222-4.

2910 Robotics

Module name/Module code:	Robotics	2910
Degree:	Mechatronic Systems Engineering:	MSE 5 2910
Module coordinator:	Prof. Dr.-Ing. T. Brandt	
Lecturer:	Prof. Dr.-Ing. T. Brandt	
Language:	English	
Place in curriculum:	Core	
Timetabled hours:	Lecture: Exercise:	2 HPW 2 HPW
Workload:	60 h attendance 60 h preparation and review 30 h exam preparation	
Credits:	5	
Recommended prerequisites:	2010 Dynamics 2904 Modelling and Simulation 2902 System Theory and Controls 2901 Drives and Power Electronics	
Module objectives:	Students know mathematical methods for describing position and orientation of robots. They are able to create direct and inverse kinematic and dynamic models of a robot and to simulate corresponding robot motions. They are able to plan complex robot motions and to realize the planned trajectories. Students are particularly aware of different kinds of Human-Machine-Interaction and are able to define the technical components of assistance systems.	
Content:	• Description of position and orientation (vectors, angles, matrices, Euler angles) • Kinematics of serial robots (Denavit-Hartenberg-convention, ambiguities, singularities, inverse kinematics), position, speed and acceleration of serial manipulators • Dynamics of robots • Design of robot trajectories • Axis controls • Force-based controls • Human-Machine-Interaction (Haptic communication, visual communication) • Applications	
Assessment:	Written examination or oral examination	
Forms of media:	Webex/Moodle	
Literature:	Mark W. Spong; Seth Hutchinson; Mathukumalli Vidyasagar: Robot Modeling and Control, Wiley & Sons, 2006, ISBN: 978-0471649908 John J. Craig: Introduction to Robotics: Mechanics and Control, Pearson Education, 3rd edition, 2009, ISBN-10: 8131718360	

2911 Introduction to Scientific Methods in Mechatronics

Module name/Module code:	Introduction to Scientific Methods in Mechatronics 2911
Degree:	Mechatronic Systems Engineering: MSE 7 2911
Module Coordinator:	Head of degree program
Lecturer:	Prof. Dr. A. von Bubnoff
Language:	English
Part of Curriculum	Elective
Timetable hours	Lecture 1 HPW Practical Training 1 HPW
Workload	150 h
Credits:	5
Recommended prerequisites::	none
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:	Examintation
Forms of media:	Board, Power Point, Computer Lab
Literature:	Karl R. Popper: The Logic of Scientific Discovery, ISBN 978-0415278447, reprint 2004, Taylor & Francis Douglas Montgomery, George Runger: Applied Statistics and Probability for Engineers. SI Version. 5th edition, Wiley, 2011 Further Readings: Geoffrey Vining, Scott Kowalski: Statistical Methods for Engineers. 3rd edition. Brooks/Cole, 2011 Douglas Montgomery: Introduction to Statistical Quality Control. 5th edition. Wiley, 2005

2912 Optical Systems

Module name/Module code:	Optical Systems	2912
Degree:	Mechatronic Systems Engineering:	SE 4 2912
Module coordinator:	Prof. Dr. G. Bastian	
Lecturer:	Prof. Dr. G. Bastian	
Language:	English	
Place in curriculum:	Focus Field Subject	
Timetabled hours:	Lecture: Exercise: Practical Training	2 HPW 1 HPW 1 HPW
Workload:	60 h attendance 45 h preparation and review 45 h exam preparation	
Credits:	5	
Recommended prerequisites:	2902 System Theory and Controls	
Module objectives:	Students have a general view of optical systems and interaction of optical components. They are able to understand and classify the function of such apparatus as optical microscopes and data storage devices, together with measuring techniques, lithography and laser machining. Students master the design of optical systems with simple examples learnt with numerical aids.	
Content:	Aside from fundamentals of propagation of light, refraction and diffraction as well as spectroscopy, the peculiarities and concepts of practical optical systems are discussed and demonstrated by various examples.	
Assessment:	Written or oral examination	
Forms of media:	Whiteboard, PowerPoint, Projector	
Literature:	Course materials from the lecturer E. Hecht: Optics (Addison Wesley), 2003, ISBN 0805385663 G. R. Fowles: Introduction to Modern Optics, Dover Publications, ISBN 0486659577	